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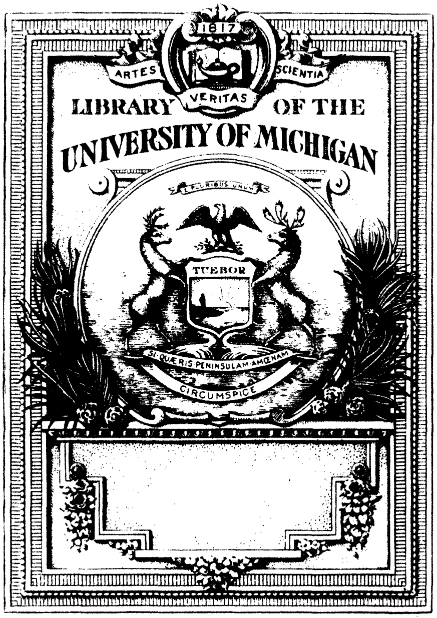

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WITH 80 PLATES AND 19 TEXT FIGURES

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THE PHILIPPINE
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VOL. 52 SEPTEMBER, 1933 No. 1

PHILIPPINE RICE-MILL PRODUCTS WITH PARTICULAR REFERENCE TO THE NUTRITIVE VALUE AND PRESERVATION OF RICE BRAN

By AUGUSTUS P. WEST and AURELIO O. CRUZ
Of the Bureau of Science, Manila

TEN PLATES AND ONE TEXT FIGURE

Rice serves as the principal food for people of the Far Eastern countries. In the Philippines the diet of the masses consists largely of rice and is more or less deficient in fats, proteins, and vitamins. This investigation of Philippine rice-mill products, particularly rice bran, was undertaken with the idea of endeavoring to supply the present dietary deficiency.

In the Philippine process of milling rice the hull is first removed leaving the kernel which is somewhat colored and commonly called unpolished rice. The unpolished rice does not keep well because, when stored, the fats in it become rancid. Again the unpolished rice becomes infested with insects which destroy the outer mealy layer of the grain. To produce white polished rice, which can be handled without commercial hazard, the rice kernel is passed through a combined scraping and polishing process. This removes the outer portion of the kernel together with the embryo. That portion of the kernel removed during the polishing process is called rice bran. The bran is also known locally as darak, tikitiki, or rice polishings.

Rice bran is the most nutritious part of the rice since it contains fats, proteins, and vitamins. The fats in rice bran are about the same as those in peanuts which are considered quite nutritious. The proteins are very similar to meat proteins since they contain in their make-up about the same important amino acids. Rice bran contains vitamin B_1, which prevents beriberi, and vitamin A, which prevents eye afflictions and general ill-health. It also has the antisterility vitamin E.

At present rice bran is very cheap and is used for feeding cattle and poultry. Millers sometimes dilute the bran with rice hulls in order to dispose of the hulls with profit. Bran, which has been adulterated with rice hulls, is not suitable for use as an edible product because the hulls have an irritating effect when taken internally.

Bran flours are considered quite nutritious and are very popular in the United States and other countries. This would naturally suggest the use of rice bran for human consumption, especially since the bran is very much cheaper than flour. Several American teachers informed us recently that some years ago in the Philippine provinces they tried to make a bran flour by mixing rice bran with wheat flour. Although this mixture made very good bread and cakes they discontinued using it because they found it difficult to obtain a regular supply of high-grade bran. Sometimes the bran was fresh and at other times it was not.

The reason that rice bran has not become a popular human food is probably due to the fact that it contains a quantity of vegetable fatty oil (rice oil). When the rice bran is stored the oil becomes rancid and the bran acquires a disagreeable taste. Millers often pile fresh bran on top of stale bran. To be sure of getting fresh bran one should really go to the mill and take the bran as it comes fresh from the polisher.

The decomposition of the fatty oil in rice bran is due to the action of moisture in the presence of vegetable tissue which contains fat-splitting enzymes. We found that rancidity may be prevented by heating the fresh bran at a temperature of about 105° C., for three hours and storing it in moisture-proof containers which preserve the bran and prevent access of insects. Heating the bran removes moisture and stops the destructive action of enzymes. This prevents decomposition and subsequent rancidity of the fatty oil contained in the bran. The heating also destroys any mold spores, insects, or insect eggs which may be in the bran but does not affect the vitamins.

Bran treated in this manner is slightly darker in color than the fresh, raw bran but it has a pleasanter and sweeter odor and flavor than the raw bran. It does not become moldy or rancid; in fact, it may be kept in a fresh condition for a considerable length of time without any appreciable deterioration.

In preparing rice bran for storage it is advisable to use a specially constructed cooker containing a stirrer. Stirring the bran while heating facilitates the removal of moisture. In outlying districts where proper cooking facilities are not available the bran may be heated cautiously in a frying pan over a low fire. The bran should be stirred and the heating continued for perhaps an hour until it turns slightly darker in color. After heating, the bran should then be placed in a can or glass jar which may be closed tightly to prevent access of moisture. Bran, thus prepared, keeps for about a week or more.

Miss Maria Y. Orosa, of the Bureau of Science, has prepared excellent cakes, cookies, and bread from mixtures of wheat flour and rice bran. She used fresh bran and also bran which had been heated and stored for two months. The results were the same in each case. These bakery products were very satisfactory in texture and quite tasty.

For people who do not fancy the natural flavor of rice bran this may be toned down considerably by diluting the bran with wheat flour. A mixture of wheat flour (3 parts) and rice bran (1 part) makes a good combination for bakery products such as bread and cakes. When used alone rice bran, lacking gluten, does not make bread which will rise. The addition of wheat flour serves not only to dilute the bran but also to supply the gluten necessary for making bread.

The bran flavor may be still further neutralized or entirely disguised by using other characteristic flavors, such as ginger, cinnamon, or chocolate. Bran cookies made with these flavors are very tasty and since they contain vitamins they are quite nutritious.

In the Philippines beriberi is a very common and fatal disease among the poorer classes who live on a diet that consists principally of polished rice and is deficient in vitamin B_1. For a number of years the Bureau of Science has been making a standard extract of rice bran (tikitiki extract) which contains vitamin B_1. This extract is widely used for curing or preventing beriberi. It has been estimated that for adults approximately 30 grams of high-grade rice bran contain about enough of the antineuritic vitamin B_1 for their daily requirements as a preventative of beriberi. This is about equivalent to 11 level (not heaping) teaspoonfuls of bran or approximately 2 cubic centimeters of standard rice-bran extract. More than 111,000 tons of fine rice bran are produced annually, in the Philippines, as a rice-mill by-product. As a preventative of beriberi this amount is about sufficient for all the people who need the bran for its medicinal value and also for others who might benefit by using it.

In a very few localities in the Philippines the people have for years been used to eating a kind of cake made from a mixture containing some fresh rice bran. If this use of rice bran as a human food could be popularized and the people all over the Islands become accustomed to eating bakery products or other foods containing rice bran then deaths from beriberi would be a rarity. It would not be necessary for the poorer classes to take extract of rice bran as a preventative or cure for beriberi.

Rice bran produced at present in the Philippines is not taken care of properly and much of it is allowed to spoil and is wasted. By utilizing this by-product of the rice mills as a food the health of the people would be generally improved. They would be getting not only vitamin B_1, which prevents beriberi, but also vitamins A and E and proteins similar to meat proteins. The children would be healthy and vigorous and would not appear to be improperly nourished. Moreover, by using a domestic by-product the Filipinos would be developing the natural resources of their own country and the importation of rice and other foodstuffs from foreign countries would be greatly diminished.

An outline of our investigation of Philippine rice-mill products and particularly rice bran is as follows:

OUTLINE OF INVESTIGATION

Rice cultivation.
Rice straw.
Philippine process of milling rice.
    Results in Philippine rice mills.
    Yields of Philippine rice-mill products.
Rice starch.
Rice hulls.
Polished and unpolished rice.
Nutritious parts of the rice grain.
    Embryo and aleurone layer.
Rice bran.
    Bran with rice hulls.
Rice oil (fats) in rice bran.
    Yield of rice oil.
    Composition of rice oil.
    Production of rice oil.

Vitamins in rice bran.
  Vitamin B_1.
  Rice-bran (tikitiki) extract.
  Vitamin A.
  Vitamin E.
  Vitamin D in irradiated rice oil.
  Chicken perosis.
  Commercial importance of vitamins in rice oil.
Proteins in rice bran.
Rice bran lacks gluten.
Unbalanced mineral constituents.
Nutritive value of rice bran.
  Rice bran as a cattle food.
  Rice bran as a human food.
  Rice bran as a preventative of beriberi.
Deterioration of rice bran.
  Insect infestation.
  Decomposition of rice oil.
Preservation of rice bran.
  Preliminary heating experiments.
  Wrappers for heated bran.
  Enzymes in rice bran.
  Testing fat-splitting-enzyme activity.
  Temperature and time of heating rice bran.
  Bacteria in rice bran.
  Sieving rice bran before heating.
  Rice-bran cooker.
  Heating bran in outlying districts.
Summary.

RICE CULTIVATION

There are many varieties of rice grown in the Philippines. According to habitat, method of cultivation, and general properties these numerous varieties are usually classified in terms such as upland and lowland rice, glutinous and nonglutinous. They are identified by certain trade names, such as Macan 1 (official No. 527), which are recorded as permanent numbers in the Philippine Bureau of Plant Industry. The different varieties are distinguished by their principal physical characteristics such as length, width, and thickness of the grain, the color of the hull and tips, flavor, and other properties. In general the late-maturing varieties give a larger yield per hectare than the early-maturing varieties.

Various methods are used for cultivating rice in the Philippines. One very common practice is to plant the rice in seed beds and later transplant the seedlings to the rice paddy (field). Chemical changes which occur during the ripening of rice grains have been studied by Tadokoro and Abe.[1] In their report they refer to previous work along this line.

When the growing rice reaches maturity (Plate 1) it is cut and stacked in the field in well-ventilated shocks and allowed to remain there about a month in order to cure the grain (Plate 2, fig. 1). Changes, not well understood, take place during the curing process. If the grain is not cured thoroughly, before threshing, it heats during storage and the moisture content increases. As a result it is likely to spoil.

Good accounts of the cultivation of rice in the Philippines are given by Copeland,[2] Camus,[3] and Mendiola.[4] Literature references concerning the experimental work on rice in the Philippines have been compiled by Capinpin and Mendiola,[5] and also Alvarado.[6] Kondo and Isshiki [7] have recently published a rather comprehensive index of rice literature.

TABLE 1.—*Area planted and yields per hectare of paddy rice produced in the Philippines during the years 1921 to 1930.*[a]

Year.	Area planted.	Yield per hectare.	Yearly production.
	Hectares.	*Cavanes.*	*Cavanes.*
1921	1,673,380	25	
1922	1,661,430	26	
1923	1,675,870	26	
1924	1,737,910	24	
1925	1,725,500	26	
1926	1,755,920	27	
1927	1,807,060	27	
1928	1,786,960	27	
1929	1,775,460	28	
1930	1,812,800	28	
Average	1,741,229	[b] 26.4	[b] 45,968,445

[a] These data were compiled from the annual reports of the Philippine Bureau of Agriculture and Bureau of Plant Industry.

[b] 1 cavan (including sack) weighs 44 kilos; 1 metric ton = 1,000 kilos; 45,968,445 cavanes x 44/1,000 = 2,022,611 metric tons.

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[1] Journal, Faculty of Agriculture, Hokkaido Imperial University, Sapporo, Japan 28 (1930) 350.

[2] Rice (1924) 220.

[3] Philip. Bur. Agr. Bull. 37 (1921).

[4] A Manual of Plant Breeding for the Tropics. College of Agriculture, University of the Philippines, Los Baños (1926) 41.

[5] A bibliographical index of the College of Agriculture contributions on agricultural crops, Philip. Agr. 15 (1927) 493.

[6] Philip. Bur. Agr., Philippine Agricultural Bibliography, part 1 (1916) 27.

[7] Ber. d. Ohara Inst. f. Landw. Forsch. 5 (1932) 325.

In Table 1 are given the area planted and yields per hectare of paddy (unhulled) rice produced in the Philippines during the years 1921 to 1930. For these ten years the average yearly production was 45,968,445 cavanes, which is equivalent to 2,022,611 metric tons.

RICE STRAW

Rice straw is obtained as a by-product in threshing rice. In the Philippines rice straw is used as packing material, bedding for cattle, fuel in finishing pottery, for making mats, brooms, sandals, and for various other purposes. Rice straw serves as a good bedding for the cultivation of edible mushrooms.[8]

Experiments on the use of Philippine rice straw as a raw material for the manufacture of paper were carried out by Reyes and Cruz.[9] They estimate that enough rice straw is produced in Bulacan Province alone to supply a 10-ton paper mill. Analysis of the rice straw from Bulacan Province is given in Table 2.

TABLE 2.—*Composition of Philippine rice straw.*[a]

Constituent.	Per cent.
Moisture	9.84
Ash	15.23
Fats and waxes	1.86
Cellulose	37.84
Aqueous extract	13.66
Pectose bodies	21.57
Total	100.00

[a] Reyes, F. D., and A. O. Cruz, Philip. Journ. Sci. 38 (1929) 374.

Philippine rice straw makes a very good tissue paper. Reyes and Cruz found that paper made from Philippine cogon grass is stronger than that made from rice straw. However, rice straw requires for digestion about one-third as much caustic soda as cogon and is easier to bleach. In the Philippines where chemicals are expensive this is a decided advantage. Again, since rice straw is a by-product in threshing rice no extra labor of cutting the straw is required as is necessary in the case of cogon grass.

PHILIPPINE PROCESS OF MILLING RICE

There is quite a difference in the appearance and arrangement of machinery in the numerous Philippine rice mills (Plate

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[8] Vicencio, A., Philip. Agr. and For. 5 (1916) 119.

[9] Philip. Journ. Sci. 38 (1929) 367.

2, fig. 2, and Plate 3). Some mills are more or less home-made, while others have very modern equipment. All of these mills, however, carry on the same operations and produce polished rice with rice hulls and rice bran as the principal by-products.

The milling of rice (fig. 1) consists essentially in gradually breaking up the rice grain (paddy or unhulled rice) into products which are separated by a number of large shaking sieves. The local Tagalog names for Philippine rice-mill products are as follows:

	Local name.
Rice grain (paddy or unhulled rice).	Palay.
Rice hulls.	Ipa.
Unpolished rice (rice kernel).	Pinawa.
Rice bran.	Darak, tikitiki, polishings.
Finely broken grain.	Binlid.
White polished rice.	Bigas.

In the Philippine process of milling rice the grain (paddy rice) is first passed through a cleaning sieve that removes trash and straw. The paddy rice is then carried to the rice huller. This breaks the hulls which inclose the rice kernel (unpolished rice). Some paddy rice grains usually pass through the rice huller without the hulls getting broken. The mixture (hulls, unpolished rice, and paddy rice) emerging from the rice huller is then sieved to remove tips, very finely broken grain, and small pieces of hulls. The mixture is then carried forward to the blower which is the next unit in the process. This is a special compartment. It contains a fan which blows the hulls out into an exit tube where the hulls are usually carried to the boiler to be used as fuel. The unpolished rice containing some paddy rice then drops to the separator sieve. This separates the unpolished rice from the paddy rice which is carried back to the rice huller.

The unpolished rice is next taken to the polisher. Some mills have two polishers. In passing through the polisher the surface of the grain is scraped with an abrasive thus removing the seed coat together with some of the outer portion of the rice kernel. The germ of the rice grain, which is rich in oil, is dislodged and also goes with the polishings (bran). In addition to the scraping procedure the grain is also polished with rubbers in passing through the polisher. At the bottom of the rice polisher there are two exit tubes. The white polished rice emerges from the polisher through one of these exit tubes and the rice bran through

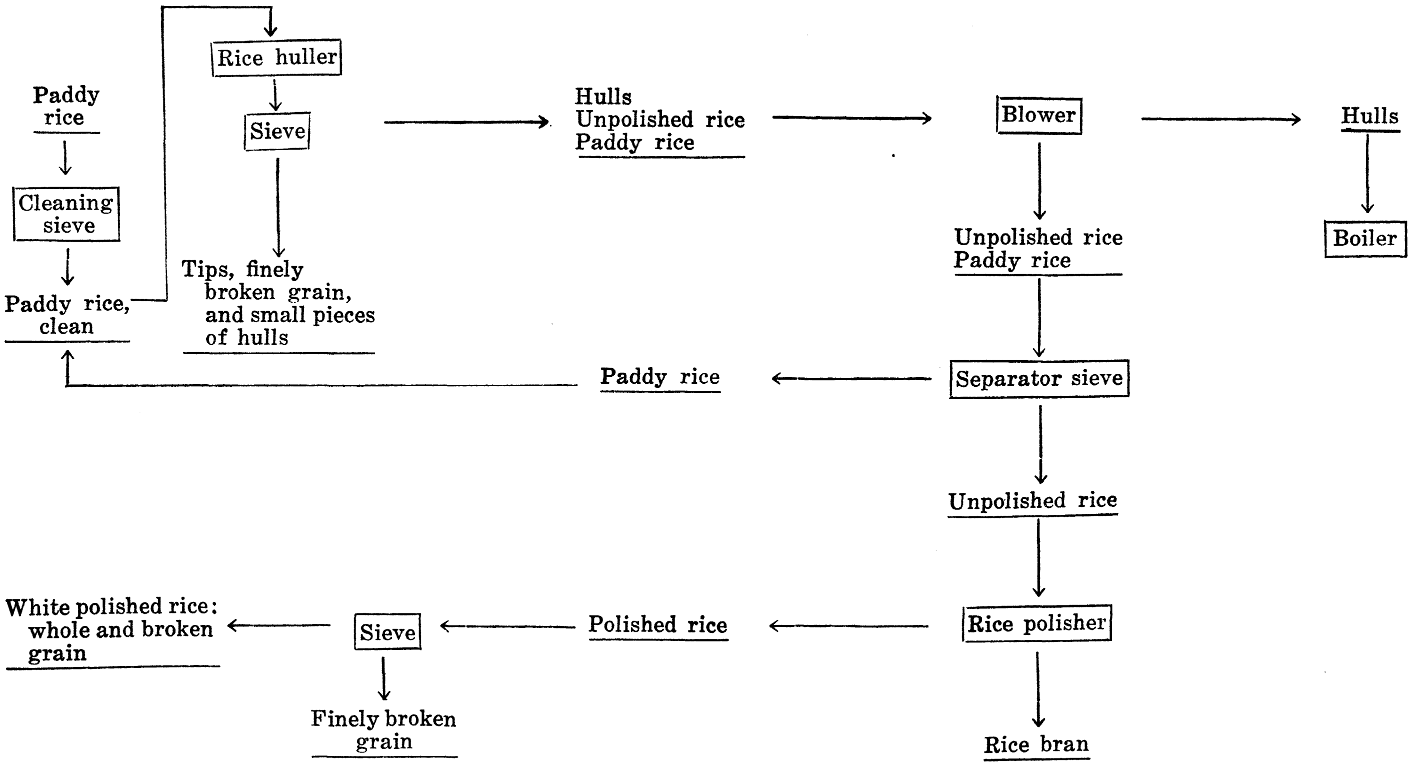

FIG. 1. Outline showing Philippine process of milling rice.

Rice-mill products: Polished rice, hulls, bran, and finely broken grain; also unpolished rice when desired.

the other. The white polished rice is next sieved to remove the very small broken grain (binlid).

The milling of rice is really a very clean process. From the time the paddy rice enters the mill until the polished rice and rice bran emerge from the mill these rice-mill products are not handled by laborers. The whole process is carried on automatically by machinery.

For power many mills have a steam engine and use the rice hulls as fuel to heat the boiler. Recently, however, some mills have introduced oil-burning engines.

In addition to the power house the four other essential parts of a rice mill are the rice huller, the blower, the separator, and the polisher. The rice huller consists of two iron disks. One is placed just above the other and the two are separated by a very small space. Artificial stone covers the lower surface of the top disk and the upper surface of the bottom disk. The top disk remains stationary while the bottom disk revolves. The whole apparatus is arranged so that the distance between the two stone surfaces can be adjusted by means of hand wheels which raise or lower the bottom disk. The paddy rice is poured into the rice huller through a hole in the middle of the top disk and falls on the lower revolving disk which throws it away in all directions. The revolving disk then grinds the grain around and breaks the hulls. The distance between the two disks should be arranged very exactly as otherwise the rice kernel may be crushed or the hulls not well broken. The rice huller is one of the most important parts of a rice mill since upon it depends the quantity of rice obtained from a given amount of whole grain. In Plate 4, fig. 1, is shown a rice huller opened and the two stone surfaces exposed, fig. 2 shows the rice huller closed.

The rice polisher (Plate 5) is a rather ingenious apparatus. It consists simply of an inverted frustum of a cone (1) set inside of a wire screen (2). The cone and the screen are inclosed in a cylindrical iron container. Before taking the photograph (Plate 5) a portion of the wire screen and a portion of the outside iron container were removed to show the abrasive cone inside. The top and side surface of the cone are covered with an abrasive prepared by mixing small pieces of emery with water glass (sodium silicate). Attached to the inner (cone) side of the wire screen and some distance apart are several vertical rubber strips (3). The cone, supported by a main shaft, is made to rotate rather rapidly. For a medium-sized cone the rate is about 300 to 400 revolutions per minute. A stream of unpolished rice is allowed to fall on top of the cone. In descending through the polisher the grain (rice kernel) is whirled around in the space between the cone and the screen. The abrasive on the cone scrapes the surface of the grain, while the rubber strips, on the screen, polish the grain. The white grain, scraped and polished, emerges from the opening at the bottom of the apparatus, while the bulk of the scrapings (polishings or bran) passes through the wire screen. The bran which thus accumulates outside the screen is pushed, by a rotating slide, to an exit tube where it falls out.

A tube, placed at the side of the polisher, connects the space outside the screen with an exhaust fan. The fan draws a current of air through the screen. This air current prevents the polished rice from getting too hot and also removes most of the very fine bran dust that tends to adhere to the polished rice.

The degree of scraping the grain depends upon the adjustment of the cone. By lowering the cone the space between the cone and screen is made smaller and the progress of the grain through the polisher is retarded. The grain thus gets a more thorough scraping. By means of adjustment screws the rubber strips on the wire screen may be projected inward toward the cone. This also retards the progress of the grain, giving it a more thorough polishing and scraping.

In removing hulls from the paddy rice (hulling process) some of the rice kernels are broken. These broken kernels are passed through the rice polisher with the whole kernels. When the polished rice is sieved the larger pieces of broken polished rice remain with the unbroken polished rice while the very small pieces (binlid) together with some bran are removed. Small pieces of grain are usually sold as chicken food or used for making starch. Millers usually do not keep an accurate account of this stock which is comparatively small. The small pieces of broken polished rice serve as a good material for fermentation and so this kind of rice (brewer's rice) may be used for making fermented beverages. In Japan the manufacture of saké from rice is an old established industry.

In the Philippines the rice sold in the markets, stores, and tiendas is usually a mixture of the whole and partly broken polished rice. The millers do not ordinarily separate this mixture.

In isolated districts in the Philippines miniature rice mills, commonly known in Tagalog as kiskisan, are sometimes used for milling small amounts of rice. In these mills the separation of bran and hulls is usually not very complete and consequently a low grade of bran, unsuitable for edible purposes, is obtained. In order to ascertain if the grain has been milled properly and the fresh bran is not diluted with hulls the bran should be tested as explained later.

Results in Philippine rice mills.—In milling rice the quantity and quality of the finished product depend upon the method of milling, the efficiency of the mill machinery, the variety of rice milled, and the condition of the rice before milling. During the process of milling some lots of rice break up to a much greater extent than others. The quantity and quality of the polished rice are therefore quite variable. In order to get a product of approximate average grade it is a very common practice in the Philippines to mix different varieties of rice before milling. However, one may occasionally visit a mill when they are running only one variety.

The results of milling rice in some Philippine mills are given in Table 3. The day these samples were taken the mills we visited happened to be running the macan variety of rice except mills numbered 1, 10, and 12 which were milling the elon-elon variety and No. 13 which was milling mixed varieties ("ordinario" rice).

As shown by the data the moisture content of the paddy (unhulled) rice varied somewhat due to the conditions and time allowed for curing and storing the paddy rice before milling. The average moisture content of these fourteen samples was 9.83 per cent.

Assuming that the paddy rice has been cured properly and is in suitable condition for milling then data on the rice-mill products, as recorded in Table 3, afford a convenient means for checking up the efficiency of the principal mill machinery—the rice huller, blower, separator, and polisher.

The lots of paddy rice milled in all of the fourteen mills did not vary greatly in moisture content and appeared to have about the same good physical condition. It would seem that the results obtained in the different mills are comparable.

TABLE 3.—*Results in some Philippine rice mills.*

Quality of mill products.	Mill.							
	1	2	3	4	5	6	7	8
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Paddy rice: Moisture	11.02	9.90	10.01	9.63	9.62	9.49	9.69	9.93
Unpolished rice:								
Paddy rice	0.10	0.26	0.06	0.04	0.04	0.05	0.15	0.73
Hulls	0.02			0.01	0.07			
Fragments of stones	0.04	0.02	0.01		0.09	0.07	0.05	0.06
Whole grains	89.60	96.70	92.50	97.60	78.00	89.90	84.90	95.10
Broken grains	10.24	3.02	7.43	2.35	21.80	9.98	14.90	4.11
Rice bran: Moisture	8.69	8.68	8.07	8.48	8.15	8.31	8.05	7.75
Rice bran (sieved, 30 mesh):								
Fine bran	84.00	83.50	82.00	82.00	84.70	70.70	89.50	85.50
Coarse material	16.00	16.50	18.00	18.00	15.30	29.30	10.50	14.50
Polished rice, finished product:								
Whole grains	75.80	89.50	85.80	84.00	76.50	84.40	67.50	74.90
Broken grains	24.20	10.50	14.20	16.00	23.50	15.60	32.50	25.10
Variety of rice [a]	Elon-elon.	Macan.	Macan.	Macan.	Macan.	Macan.	Macan.	Macan.

[a] These samples of rice-mill products were collected during the dry season on a clear hot day, April 17, 1933.

TABLE 3.—*Results in some Philippine rice mills*—Continued.

Quality of mill products.	Mill.							
	9[b]	10[c]	10[d]	11[c]	11[d]	12	13	14
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Paddy rice: Moisture	9.15	9.89		9.88		9.25	10.46	9.65
Unpolished rice:								
Paddy rice	0.03	0.29		0.01		0.01	0.03	0.23
Hulls	0.02	0.02		0.01		0.01	0.01	0.30
Fragments of stones	0.03	0.05		0.13			0.16	0.03
Whole grains	82.90	89.60		87.60		83.20	86.30	91.40
Broken grains	17.02	10.04		12.25		16.78	13.50	8.04
Rice bran: Moisture	8.20	8.03	8.30	8.66	8.14	8.10	8.36	8.44
Rice bran (sieved, 30 mesh):								
Fine bran	86.00	87.50	81.00	90.00	83.50	95.00	86.50	85.00
Coarse material	14.00	12.50	19.00	10.00	16.50	5.00	13.50	15.00
Polished rice, finished product:								
Whole grains	68.10	63.30		67.50		79.30	79.40	79.90
Broken grains	31.90	36.70		32.50		20.70	20.60	20.10
Variety of rice	Macan.	Elon-elon.		Macan.		Elon-elon.	Mixed.	Macan.

[b] In this mill the rice was polished twice with the same polisher.

[c] This mill had two polishers.

[d] Results from the second polisher.

The unpolished rice contained a very small amount of foreign matter such as paddy rice, hulls, and fragments of stones. The amount of this foreign matter was determined by taking a 200-gram sample of the unpolished rice and carefully separating out, by hand, the individual foreign matter which was then weighed on a chemical balance. The weights obtained divided by 2 gave the percentages.

Samples of unpolished rice from most of the mills contained only a very small amount of rice hulls. This showed that the blowers were working very well. The unpolished rice also had very little paddy (unhulled) rice, showing that the separators were operating very efficiently.

The percentage of broken grains in the unpolished rice was determined by taking a 100-gram sample and separating, by hand, the whole grains which were weighed. The weight of the whole grains was then added to the total weight of the foreign matter (paddy rice, hulls, and stones). Subtracting this sum from 100 gave the percentage of broken grains.

In mills 2 and 4, the unpolished rice contained only a very small amount of broken grains. This indicated that the rice huller was working efficiently in these mills. The unpolished rice in mill 5, however, contained a considerable amount of broken grains indicating that the huller was working poorly and was probably adjusted too tightly.

The average moisture content of all the samples of rice bran was 8.28 per cent, which is 1.55 per cent less than the average for the paddy rice. During the polishing process the bran is heated and loses moisture, consequently the moisture content of the bran is less than that of the paddy rice.

We sieved the rice bran, obtained from these mills, through a 30-mesh sieve and determined the percentage of fine bran which passed through the sieve and also the percentage of coarse material retained by the sieve. The average percentage of fine bran was 84.67 and of the coarse material, 15.33. Before entering the polisher the rice kernel (unpolished rice) contained only a small amount of foreign matter, consequently the coarse material in the bran consisted almost entirely of fragments of rice kernels.

Bran from mill 12 contained less coarse material than bran from the other mills. Evidently the polisher in this mill had a very good screen as only a small amount of finely broken rice kernels passed through the screen with the bran. The polisher in mill 6 probably had a very poor screen with holes in it as a considerable amount of broken rice kernels was found in the bran which passed through the screen.

In mills which had two polishers the bran from the second polisher was slightly lighter in color than the bran from the first polisher because it contained more starchy material. The bran from the second polisher also had more finely broken rice kernels than bran from the first polisher. Probably the second polisher was adjusted somewhat tighter than the first polisher.

The amount of whole and broken grains in the polished rice (finished product) was determined by taking a 100-gram sample and separating, by hand, the whole grains from the broken grains. These different lots were then weighed to get the percentages.

The polished rice from mills 9, 10, and 11, contained more broken grains than the polished rice from the other mills. In these three mills the grain was polished twice and each time the rice went through the polisher some of the grains were broken. Mill 2 produced a polished rice which had the least amount of broken grains. The polished rice from this mill was slightly darker in color than the polished rice from the other mills, indicating that this rice was not polished as much as the others which appeared to have had about the same degree of polishing.

According to our results the macan variety of rice mills better than the elon-elon, because the macan gave less broken grains than the elon-elon. Philippine rice millers, however, believe that the elon-elon is the better milling rice. Mr. G. M. Reyes, of the Bureau of Science, examined our samples of elon-elon and found they contained about 5 to 8 per cent of varieties which were not elon-elon. This would, perhaps, account for the fact that the elon-elon did not mill as well as we expected.

In the Philippine process of milling rice the grain is broken in both the rice huller and polisher as shown by the data given in Table 4. The breakage may be about the same in each machine or it may be greater in either the huller or polisher.

In mill 3 the amount of grains broken in the polisher was very nearly the same as in the huller. In mill 4 the polisher broke considerably more grains than the huller while in mill 5 the breakage was much greater in the huller than in the polisher. In calculating these results the percentage of grains broken in the polisher was determined by subtracting the percentage of broken grains in the unpolished rice from the percentage of broken grains found in the polished rice (finished product).

These percentage figures are, of course, only approximate as, during the milling process, some grains will be crushed or broken into fragments of rice kernels which were not considered in the breakage calculation. The results given in Table 4, do show, however, where the breakage of grains occurs mostly in the different mills. By adjusting more exactly the particular machine which causes most of the breakage the amount of broken rice grains may be considerably decreased. Rice that contains a considerable quantity of broken grains sells for a lower price than rice which has only a small amount of broken grains.

TABLE 4.—*Breakage of Philippine rice grains (macan variety) in rice huller and polisher.*

Mill.	Grains broken in huller.	Grains broken in polisher.	Polished rice (finished product).	
			Broken grains.	Whole grains.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
2	3.02	7.48	10.50	89.50
3	7.43	6.77	14.20	85.80
4	2.35	13.65	16.00	84.00
5	21.80	1.70	23.50	76.50
6	9.98	5.62	15.60	84.40
7	14.90	17.60	32.50	67.50
8	4.11	20.99	25.10	74.90
9	17.02	14.88	31.90	68.10
11	12.25	20.25	32.50	67.50
14	8.04	12.06	20.10	79.90
Average	10.09	12.10	22.19	77.81

In the Philippines the rice is graded by observation and not by machines. A dealer simply takes a handful of polished rice, spreads it over his open hand and estimates approximately the proportion of broken grains and the degree of polishing. Some dealers are said to be quite expert in grading. However, occasionally you may find in one market a sample of second-class rice which is better than a first-class sample in another market. So the grades sold in different markets are not always uniform.

The Philippine process of milling rice is quite different from that used in the United States.[10] In the Philippines the scraping and polishing of the grain are done in one machine—the rice polisher. In the United States these two operations are performed in separate machines. Again, in the United States it is often customary to coat the polished rice with glucose and talc which gives the grain a brighter luster. The polished rice is then graded mechanically into grains of different sizes. These extra operations are not performed in the Philippines.

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[10] Wise, F. B., and A. W. Broomell, U. S. Dept. Agr. Bull. 330 (1916). Fraps, G. S., Texas Agr. Exp. Sta. Bull. 191 (1916).

TABLE 5.—*Average production of whole and broken polished rice grains in Philippine and American rice mills.*

Kind of rice grains.	Variety of polished rice.					
	Philippine mills.				American mills.[a]	
	Rice polished once.		Rice polished twice.		Honduras.	Japan.
	Macan.	Elon-elon.	Macan.	Elon-elon.		
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Whole grains	80.31	77.55	67.80	63.30	51.69	82.57
Broken grains	19.69	22.45	32.20	36.70	48.31	17.43
Total	100.00	100.00	100.00	100.00	100.00	100.00

[a] Wise, F. B., and A. W. Broomell, U. S. Dept. Agr. Bull. 330 (1916).

In Table 5 is given a comparison of the amount of whole and broken polished rice grains obtained during the milling of rice in Philippine and American mills. As shown by the data for the elon-elon and macan varieties of Philippine rice the percentage of whole grains produced in the Philippine mills compares very favorably with the best results obtained in the American mills.

TABLE 6.—*Yields in Philippine mills of polished rice, bran, and hulls from paddy rice.*

Constituent.	Mill 15.	Mill 16.	Average.
	Per cent.	*Per cent.*	*Per cent.*
Polished rice	64.8	66.1	65.45
Rice bran[a] (not sieved)	6.8	6.2	6.50
Rice hulls[b]	28.4	27.7	28.05
Total	100.0	100.0	100.00

[a] Contains some finely broken grain (binlid).

[b] Data for the hulls include the percentage of finely broken grain produced in the rice huller.

Yields of Philippine rice-mill products.—The yield of polished rice varies somewhat. Some varieties give a slightly higher yield than others. In the larger mills they generally estimate that 100 cavanes (44 kilos each) of whole, mixed rice will yield roughly about 50 cavanes (57 kilos each) of milled polished rice. In Table 6 are given the yields of polished rice, bran, and hulls obtained from paddy rice in two of the large Philippine mills. The average of the results obtained in these mills is about the average of Philippine milling practice. As shown by the data (Table 6) there is a slight variation in the yields. For these particular runs mill 15 gave a slightly lower percentage of polished rice but a higher percentage of bran and hulls than mill 16. By adjusting the polishers to get a more thorough scraping of the grain there is obtained a very white grade of rice with somewhat less yield while the amount of bran is slightly increased.

Philippine rice, when milled, yields an average of 6.50 per cent of rice bran. When sieved, the crude bran gives 84.67 per cent of fine bran and 15.33 per cent of coarse material. The proportion of fine bran and coarse material in 6.50 per cent of rice bran (not sieved) would be as follows:

$6.50 \times 0.8467 = 5.50$ per cent fine bran.
$6.50 \times 0.1533 = 1.00$ per cent coarse material.

The estimated average yearly production of Philippine rice-mill products is given in Table 7. As shown by the data there is a very considerable amount of fine rice bran produced during the year.

TABLE 7.—*Average yearly production of Philippine rice-mill products.*

Rice-mill products.	Yields from paddy rice.	Average yearly production.[a]
	Per cent.	*Metric tons.*
Polished rice	65.45	1,323,799
Rice bran (sieved, 30 mesh):		
Fine bran	5.50	111,316
Coarse material	1.00	20,154
Hulls	28.05	567,342
Total	100.00	2,022,611

[a] Average yearly production of paddy rice is 2,022,611 metric tons (Table 1).

For a medium-sized Philippine mill running about ten hours a day during the milling season the average amount of rice milled is about 250 cavanes, or 11,000 kilos, a day. Data showing the daily production of mill products from a medium-sized mill are given in Table 8.

TABLE 8.—*Daily production of rice-mill products from a medium-sized Philippine mill.*

Mill products.	Daily production. kg.
Polished rice	7,199.5
Rice bran (sieved, 30 mesh):[a]	
Fine bran	605.4
Coarse material	109.6
Hulls	3,085.5
Total	11,000.0

[a] The crude rice bran is usually not separated by sieving into fine bran and coarse material.

RICE STARCH

Although rice starch is not strictly a rice-mill product it may be well to mention it since it is an important commercial product made from polished rice. Rice contains about 78 per cent of starch. This is a larger percentage than is contained in any other starchy material, such as wheat, maize, or potatoes. Various authorities [11] give a very good description of the manufacture of starch from rice. According to Thorpe—

> The demand for rice starch has grown chiefly because of its suitability for laundry use, and this in turn is due entirely to the fact that the rice starch granule is considerably smaller than that of any other commercial starch. When made with boiling water, too, the resulting mucilage is better adapted for "starching" than other starches.

Rice starch is used commercially for various purposes such as laundering, preparing foods, making paste, and making medicinal tablets. It is also employed extensively in the cosmetic industry for making face powders. In addition to the perfume, the principal characteristics of a good face powder are color, texture, and perfect adherence to the skin. The latter qualities impart the appearance and finish. According to Poucher,[12] the peachlike finish given to the skin by face powders is best obtained by the use of rice starch. Other starches, especially maize, are employed in cheaper powders. The particles of rice starch are much finer than those of any other cereal and consequently there is a distinct preference for rice powders. Parisian manufacturers of cosmetics rate these powders very highly and in comparing the qualities of rice powder with other powders they find the rice powder to be by far the least harmful to the skin and much smoother.

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[11] Thorpe, E., A Dictionary of Applied Chemistry 6 (1926) 374. Rehwald, F., and C. Salter, Starch-making (1926) 169.

[12] Perfumes, Cosmetics, and Soaps 2 (1929) 478 and 480.

RICE HULLS

In milling rice the hulls are obtained as a by-product. They are light in weight, neutral in odor, and have a slow combustibility. They are used for packing hygroscopic materials to prevent moisture absorption; filtering and percolating; for insulation, making insect powder, and various other purposes.

In the Philippines the rice hulls are generally used as fuel in the rice mills. They are also employed in hatching duck eggs[13] and in burning wood for charcoal.

TABLE 9.—*Analysis of Philippine rice hulls.*[a]

Constituent.	Variety of rice hulls.	
	Ramai.	Macan.
	Per cent.	*Per cent.*
Moisture	7.65	6.77
Fat (ether extract)	0.62	0.63
Protein	1.75	1.97
Crude fiber	34.97	38.92
Ash	22.29	21.69
Carbohydrates by difference	32.72	30.02
Total	100.00	100.00

[a] Analyses made by Mr. H. Taguibao, of the Bureau of Science.

In Table 9 are given analyses of rice hulls from two varieties of Philippine rice (ramai and macan). As shown by the data the hulls consist largely of crude fiber and also have a rather high ash content. Since the ash (Table 10) consists principally of silica the hulls have a very low nutritive value. It is generally believed that the hulls have an irritating effect[14] upon the stomach and intestines of animals.

On account of their very high silica content the ashes of rice hulls, when finely powdered, serve as a good polishing powder. They should also be useful for making polishing pastes and scouring soaps.

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[13] Burgos, C. X., Philip. Agr. Rev. 27 (1924) 87.

[14] Fraps, G. S., Texas Agr. Exp. Sta. Bull. 191 (1916).

TABLE 10.—*Analysis of the ash of rice hulls.*[a]

Constituent.	Per cent.
Silica oxide	95.49
Iron and alumina oxides	0.94
Calcium oxide	0.86
Magnesium oxide	0.28
Phosphorus as P_2O_5	0.36
Sodium and potassium oxides	1.58
Total	99.51

[a] Journ. Indus. Eng. Chem. News Ed. 9 (1931) 57.

Rice hulls have been found to be useful for making an edible rice cellulose. Harding[15] states:

> A recent advance in food technology is the development of a process of recovery of an edible cellulose from the hulls of rice and other cereals. Cellulose is a natural constituent of practically all vegetable foods and is really an essential dietary constituent. By adding bulk and roughage to the intestinal contents normal elimination is promoted and constipation largely prevented.
>
> In the development of a new ready-to-serve breakfast food milled rice was found to be the most desirable cereal base. Because of the low cellulose content of milled rice it was decided to reënforce the roughage content of the finished cereal by additions of a pure cellulose of suitable physical form. It was found that a satisfactory pure edible cellulose could be prepared from the hull of the rice, thus making the breakfast food an all-rice product. The cellulose of the hull is first isolated in a semifibrous form by a strong soda cook. A hydration treatment then reduces it to the proper physical form for use as an edible material.
>
> A large plant for the production of this new form of pure cellulose has been in operation for some time. It is located at Lake Charles, Louisiana, adjacent to the largest rice mill in the world.
>
> Rice cellulose as prepared for food roughage is a light, somewhat fluffy, fine, mealy material. It has a light cream color, but is easily bleached white if desired. It is odorless and tasteless. It has a mealy feel in the mouth, and although not intended to be eaten straight, when well moistened with saliva, can be swallowed without difficulty or irritation. Its ash content has been reduced to 1.0 per cent or less, although the original raw material contains about 18 per cent of ash that is largely insoluble silica. The washed product from the alkaline digestion may run as high as 99 per cent alpha-cellulose. In the finished product a part of the original compound or normal celluloses has been converted to simpler hydrated celluloses; but the freedom from impurities of non-cellulosic character entitles it to be called a practically pure cellulose.

POLISHED AND UNPOLISHED RICE

After passing the paddy (unhulled) rice through the rice huller to remove the hulls the unpolished (hulled) rice then goes through the polisher. There are several reasons for polishing rice. Polished rice has a very clean, white, and tasty appearance, whereas the unpolished rice is slightly colored and is not so attractive. Polished rice has much better keeping qualities than unpolished rice. The unpolished rice loses its flavor in a tropical climate because the fats in it become rancid. Again the unpolished rice has a tendency to get moldy and become infested with weevils and other insects, which destroy the outer mealy layer of the grain. This is the reason why the wholesale rice dealers are reluctant to handle unpolished rice. Polished rice can be handled without commercial hazard.

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[15] Journ. Indus. Eng. Chem. 20 (1928) 310.

Photographs of the paddy rice, unpolished, and polished rice of two varieties (ramai, figs. 1, 2, 3; and elon-elon, figs. 4, 5, 6) are given in Plate 6. The paddy rice of the ramai variety, fig. 1, has a shape somewhat different from that of the elon-elon, fig. 4. Both paddy grains have ridges which are also seen in the unpolished rice, figs. 2 and 5, but not in the polished rice, figs. 3 and 6. During the polishing process the brown seed coat of the rice kernel is removed, the ridges worn down, and the surface then scraped and smoothed over. This gives the surface of the polished rice a whiter and cleaner appearance than that of the unpolished rice. The germ of the grain observed in the indentation on the unpolished rice, figs. 2 and 5, is also removed during the polishing and is not seen in the photographs of the polished rice, figs. 3 and 6.

Samples of unpolished rice of numerous Philippine varieties have been analyzed.[16] The results showed a slight variation in the percentages of fat, protein, crude fiber, ash, and carbohydrates.

TABLE 11.—*Analysis of polished and unpolished rice (Macan variety).*[a]

Constituent.	Polished rice.	Unpolished rice.
	Per cent.	*Per cent.*
Fat (ether extract)	1.21	3.00
Protein (N x 6.25)	8.66	9.22
Ash	0.65	1.57
Crude fiber	0.31	0.87
Carbohydrates by difference	89.17	85.34
Total	100.00	100.00

[a] Analyses made by Mr. H. Taguibao, of the Bureau of Science. Results calculated on a moisture-free basis.

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[16] Wells, A. H., F. Agcaoili, and R. T. Feliciano, Philip. Journ. Sci. 20 (1922) 353.

Analyses of Philippine polished and unpolished rice are given in Table 11. At the time these samples were taken the mill was running the macan variety of rice. As shown by the data the unpolished rice, which still retains the seed coat and oily germ, contains somewhat more fat, protein, ash, and crude fiber than the polished rice. The polished rice, however, contains more starchy material (carbohydrates).

The effects of living on a diet composed largely of polished (highly milled) rice or unpolished (undermilled) rice are stated very clearly by Vedder and Feliciano:[17]

> Although medical authorities still differ with regard to a number of details concerning the etiology of beriberi, there is a very general consensus of opinion to the effect that beriberi is a deficiency disease, produced whenever, in the absence of an adequate mixed diet, highly milled rice is used as the main food staple, and that the disease can be prevented by the substitution of a sufficiently undermilled rice. The most striking illustration of this fact with which we are familiar is the case of the Philippine Scouts. For a number of years (1902–1909), while they were supplied with the best grade of highly milled rice, beriberi was the most important cause of admission to sick report for these native troops, the incidence often reaching as high as 10 per cent of the entire number (5,000). In 1910 the substitution of undermilled rice was made. Beriberi at once declined as a cause of admission and at the end of a year, when the substitution had been made universally effective, beriberi was completely eradicated. Since that time undermilled rice only has been furnished, and during all these years beriberi has completely ceased to appear among these troops, although they were living in the midst of a population where beriberi is very common. Similar results have been obtained in a number of civil institutions in the Philippines as well as in other countries.

The reason the unpolished rice is a preventative of beriberi is because it contains the antineuritic vitamin B_1, which prevents beriberi. During the polishing process, to produce white polished rice, most of the vitamins go with the rice bran which is removed from the grain as a by-product.

Vedder and Feliciano[18] carried out an elaborate investigation to determine a standard for unpolished rice which would prevent beriberi. Samples of unpolished rice from many varieties were analyzed and also fed to pigeons to determine their actual beriberi-producing potentialities. Pigeons were selected because they are even more susceptible to polyneuritis than the human race is to beriberi. As a result of their investigation they suggested, as tentative standards, the following chemical indices for beriberi-preventing rice:

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[17] Philip. Journ. Sci. 35 (1928) 351.

[18] Ibid.

> Any rice having 1.77 per cent of phosphorus pentoxide plus fat, but not less than 0.4 per cent phosphorus pentoxide; or any rice having not less than 0.62 per cent phosphorus pentoxide; or any rice having not less than 0.50 per cent phosphorus pentoxide and with at least 75 per cent of the external layers of the grain remaining.

Vedder and Feliciano also determined the effect of washing unpolished rice and found that for ten samples the average loss in phosphorus pentoxide was 0.25 per cent. Presumably the vitamin content of these rices was similarly reduced. They further state—

> Previous writers, including Schüffner and Kuenen and McCarrison and Norris, have shown that prolonged washing or soaking of the rice, prior to cooking, extracts and removes a considerable portion of its vitamin, and that an originally beriberi-preventing rice may be thus converted into a beriberi-producing rice. This is what would be expected, in view of the fact that the antiberiberi vitamin is very freely soluble in water . . . It is to obviate such difficulties as much as possible that we have recommended such a high standard for a beriberi-preventing rice. A lower standard would undoubtedly suffice if it were not for such factors as excessive washing, pressure cooking, and other procedures that cannot be foreseen; but the standard recommended at least provides a considerable margin of safety.

THE NUTRITIOUS PARTS OF THE RICE GRAIN (EMBRYO AND ALEURONE LAYER)

According to Vedder and Feliciano[19] the antineuritic vitamin B_1, the fat, and most of the phosphorus of the unpolished rice are undoubtedly contained chiefly in the embryo (germ) and the aleurone layer of the unpolished rice grain. Dr. J. K. Santos[20] of the Bureau of Science has recently investigated sections of polished and unpolished rice and made diagrams of these sections.

A diagram of a longitudinal section of the whole rice grain (Malagkit variety) is given in Plate 7, fig. 1. This diagram shows the embryo with its principal parts, the cotyl, plumule, and radicle.

A segment of a part (cotyl) of the rice grain embryo is given, by diagram, in Plate 7, fig. 2. As shown by the diagram this segment, which is characteristic of the whole embryo, contains a considerable number of oil droplets as well as numerous protein granules. The oil droplets are identified by the pink to red color imparted by tincture of alkanna or the brown to black color given by osmic acid. The protein granules in these cells are identified by the yellow color given by an iodine solution.

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[19] Philip. Journ. Sci. 35 (1928) 354.

[20] Philip. Journ. Sci. (in press).

A segment of a cross section of unpolished rice (Macan variety) is shown, by diagram, in Plate 7, fig. 3. This illustration shows the outside seed coat of the unpolished rice, the aleurone layer of cells beneath the seed coat, and the starch cells beneath the aleurone layer. The aleurone layer is the outermost layer of the endosperm or that part of the rice kernel that lies just beneath the seed coat. The aleurone cells in this layer contain protein granules and oil droplets. These oil droplets as well as those in the embryo comprise the rice oil which may be extracted from the bran. Starch granules in the cells beneath the aleurone layer are recognized by the familiar blue color imparted by an iodine solution. No oil droplets are found in these starch cells beneath the aleurone layer though protein granules are observed near the cell walls. The oily embryo and the aleurone layer are really the most nutritious parts of the rice grain since they contain the vitamins, the fats and also proteins.

In Plate 8 are given diagrams of the cross sections of unpolished rice (fig. 1) and polished rice (fig. 2) of the macan variety. During the polishing process the entire seed coat of the unpolished rice is removed. The embryo (germ) is also removed (Plate 6, figs. 3 and 6) as well as most of the aleurone layer of cells. Polished rice usually contains small portions (remnants) of the oily aleurone layer as shown by the diagram (Plate 8, fig. 2). The fatty oil contained in these portions of the aleurone layer becomes rancid when the polished rice is stored for some time and as a consequence the polished rice tends to lose its fresh flavor.

The degree of polishing determines how much of the aleurone layer remains with the polished rice. A highly polished rice contains very little of the aleurone layer. As suggested by Vedder and Feliciano and shown by the diagrams of Santos the polishing process removes from the rice grain the most nutritious parts which go with the rice bran (polishings).

RICE BRAN

After the paddy rice is hulled the unpolished (hulled) rice, which remains, is passed through the polisher to get white polished rice. In the Philippines the rice polishings, removed during the polishing process, are commonly called rice bran, tikitiki, or darak. This rice bran (polishings) comprises the seed coat, germ, and most of the outer (aleurone) layer of the rice kernel together with some of the starchy material beneath the aleurone layer. The rice bran contains the most nutritious parts of the rice grain for it has vitamins, fats, proteins, and the phosphorus ingredient, as well as some starchy material (carbohydrate).

Bran with rice hulls.—In making rice-bran (tikitiki) extract we find that a bran which is moisture free and contains at least 20 per cent fat gives an excellent product, so we have come to regard this kind of bran as one of standard quality.

In our inspection of Philippine rice mills we visited several where it was customary to mix ground rice hulls with the bran. As the hulls contain very little fat (less than 1 per cent, Table 9) this diluted bran would, of course, give a low fat content, less than 20 per cent.

The amount of ground hulls contained in diluted bran may be estimated approximately. Suppose a sample of diluted bran, when analyzed, gives only 15 per cent fat calculated on a moisture-free basis. How much genuine bran is in the diluted mixture? A sample containing only bran of high quality (100 per cent standard bran) has at least 20 per cent fat. The hulls may be considered roughly as having no fat. The approximate percentage of bran and hulls in the mixture is obtained by the following calculation:

$$\text{Percentage of bran} = \frac{100 \times 15}{20} = 75$$

$$\text{Percentage of hulls} = 100 - 75 \text{ or } 25$$

This sample of diluted bran consists of about 75 per cent rice bran and 25 per cent hulls or other foreign matter. This calculation is, of course, based upon the composition of a high-grade bran suitable for making excellent rice-bran extract; that is, a standard bran containing at least 20 per cent fat calculated on a moisture-free basis.

Santos [21] has recently made a microscopic study of rice bran. He found that rice hulls, when contained in the bran, may be identified as they present a characteristic appearance under the microscope. In plate 8, fig. 3, is given a microscopic view of a fragment of a rice hull showing two of the surface hairs.

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[21] Philip. Journ. Sci. (in press).

Rice bran suitable for use as an edible product should not contain any rice hulls. The hulls contain about 21 per cent of ash which consists mostly of silica. As the silica has abrasive properties, quite likely the hulls have an irritating effect upon the stomach and intestines.

In milling rice bran intended for edible purposes the mill should have a very efficient blower which will remove practically all the rice hulls from the unpolished rice. In our investigation of Philippine rice mills we found that most of the mills had very good blowers.

In purchasing bran from a rice mill it is advisable to inspect the unpolished rice before it goes through the polisher. If the grain before polishing contains no hulls then the bran removed from the grain during the polishing process will also be free of hulls unless the bran has been purposely adulterated. The bran should be taken as it comes fresh from the polisher because millers often pile fresh bran on top of stale bran so that bran lying in heaps about the mill is not likely to be very fresh.

RICE OIL (FATS) IN RICE BRAN

Yield of rice oil.—In Table 12 are given the moisture and fatty oil content of rice bran obtained from some Philippine rice mills.

TABLE 12.—*Fat content of rice bran from Philippine mills.*

Mill.	Polisher No.	Variety of rice.	Moisture.	Fat.	Fat (moisture free).
			Per cent.	*Per cent.*	*Per cent.*
17	1	Mixed	8.2	19.7	21.5
17	2	do	8.3	17.8	19.4
18	1	Elon-elon	9.1	20.9	23.0
18	2	do	9.0	17.1	18.8
19	1	Macan	8.8	19.7	21.5
19	2	do	8.2	16.3	17.8
20	[a] 1	Elon-elon	8.4	19.7	21.6
21	[a] 1	Mixed	6.9	18.7	20.1
22	[a] 1	Lamio	6.4	19.3	20.6
23	[a] 1	Macan	6.1	20.7	22.0

[a] This mill had only one polisher.

Bran from the first polisher contains somewhat more fatty oil than bran from the second polisher. During the second polishing of the grain there is naturally a tendency to remove more of the interior starchy part of the grain beneath the outer oily (aleurone) layer. The fat content of the bran will, of course, vary somewhat according to the degree of polishing. Calculated on a moisture-free basis bran from the first polisher contains over 21 per cent of fat. Where only one polisher is used the fat content of the bran is 20 per cent or more.

Composition of rice oil.—Recently the composition of rice oil obtained from the bran of two varieties of Philippine rice (hambas[22] and ramai[23]) was investigated.

The hambas rice is a lowland variety which grows fast but matures rather late. It has somewhat long grains that have an average length of 8.3 millimeters, an average width of 2.7 millimeters, and an average thickness of 1.9 millimeters. Ramai rice is also a lowland variety. It requires plenty of water for cultivation. Although it matures slowly it is the highest yielding variety in the Philippines. It has rather large grains which have an average length of 7.74 millimeters, an average width of 3.47 millimeters, and an average thickness of 2.23 millimeters. As an edible product the ramai rice is not as tasty as some varieties of rice that have smaller grains.

TABLE 13.—*Comparison of Philippine rice oil with other oils.*

Constituent.	Philippine oils.			American oils.	
	Rice (ramai).[a]	Rice (hambas).[b]	Peanut.[c]	Rice.[d]	Cotton seed.[e]
Glycerides of:					
Unsaturated acids—	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Oleic	45.3	45.6	53.9	41.0	35.2
Linolic	27.6	27.7	27.0	36.7	41.7
Saturated acids:					
Myristic	0.1	0.2		0.3	0.3
Palmitic	16.9	17.3	8.5	12.3	20.0
Stearic	2.6	1.8	3.6	1.8	2.0
Arachidic	0.5	0.7	3.4	0.5	0.6
Lignoceric	0.9	0.7	2.4	0.4	
Unsaponifiable matter	4.0	4.0	0.3	4.6	
Total	97.9	98.0	99.1	97.6	99.8

[a] Cruz, A. O., A. P. West, and V. B. Aragon, Philip. Journ. Sci. 48 (1932) 5.
[b] Cruz, A. O., A. P. West, and N. B. Mendiola, Philip. Journ. Sci. 47 (1932) 487.
[c] Cruz, A. O., and A. P. West, Philip. Journ. Sci. 46 (1931) 199.
[d] Jamieson, G. S., Journ. Oil and Fat Indus. 3 (1926) 256.
[e] Jamieson, G. S., and W. F. Baughman, Journ. Am. Chem. Soc. 42 (1920) 1197.

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[22] Cruz, A. O., A. P. West, and N. B. Mendiola, Philip. Journ. Sci. 47 (1932) 487.

[23] Cruz, A. O., A. P. West, and V. B. Aragon, Philip. Journ. Sci. 48 (1932) 5.

The composition of rice oil from bran of the two varieties of Philippine rice (hambas and ramai), which have different sized grains, is given in Table 13. These oils are very nearly identical in composition and consist principally of glycerides of oleic, linolic, and palmitic acids. They are very similar to cottonseed and peanut oils.

Rice oil has a rather dark brown color with a greenish tinge. The color is somewhat undesirable because buyers of edible vegetable oils, such as coconut oil, usually prefer an oil which is very light in color.

Production of rice oil.—The difficulty in producing rice oil commercially is that the oil is not easily expressed from rice bran. Recently we tried to express oil from rice bran by using a hydraulic press in the coconut oil mill of the Spencer Kellogg & Sons in Manila. With a pressure of about 4,000 pounds, which is commonly employed for expressing coconut oil, practically no oil was obtained from the rice bran. Since these pressure experiments were tried out Mr. C. Boysen, of Spencer Kellogg & Sons, informed us that he once expressed the oil from rice bran by using a pressure of 8,000 pounds. This high pressure would, of course, be rather expensive for an ordinary commercial process.

With the aid of expeller copra cake we were, however, able to express oil from rice bran by using a pressure of only 4,000 pounds. Expeller copra cake is the oil cake which remains after a large part of the coconut oil has been expressed from the dried copra (coconut meat) in the expeller presses. This cake still contains considerable coconut oil varying from about 10 to 15 per cent and sometimes even more. In the Philippine coconut oil mills this expeller copra cake is subjected to a second pressing in hydraulic presses to recover more of the coconut oil. The hydraulic copra cake which remains after this second pressing usually contains only about 5 per cent of coconut oil.

By mixing expeller copra cake (two parts) with rice bran (one part) and subjecting the mixture to a pressure of 4,000 pounds in a hydraulic press a mixture of coconut and rice oils was obtained. In this experiment the coconut oil, contained in the copra cake, acts as a solvent to dissolve the oil in the rice bran. This dark-colored mixed oil had an iodine number of 32.35 (Hanus). Rice oil has an iodine number of 99.5 and coconut oil an iodine number of 9. The proportion of each of these oils contained in the mixture may be ascertained by carrying out the following calculation in which X represents the percentage of rice oil and Y the percentage of coconut oil:

$$X + Y = 100$$

$$\frac{99.5\,X + 9Y}{100} = 32.35$$

This mixed oil consists of 25.8 per cent rice oil and 74.2 per cent coconut oil. Thus by utilizing the oil contained in expeller copra cake for its solvent effect the rice oil mixed with coconut oil may be obtained from rice bran by pressure.

The composition of the oil cake obtained from the mixture of expeller copra cake and rice bran is given in Table 14.

TABLE 14.—*Composition of oil cake from a mixture of expeller copra cake (2 parts) and rice bran (1 part).*[a]

Constituent.	Composition. Per cent.
Moisture	8.73
Protein (N X 6.25)	17.42
Ether extract (fat)	9.02
Ash	7.17
Crude fiber	6.51
Carbohydrates (by difference)	51.15
Total	100.00

[a] Analysis made by Mr. H. Taguibao, of the Bureau of Science.

Rice oil produced commercially by expression should be filtered thoroughly immediately after it is obtained from the bran. When allowed to remain in contact with vegetable tissue containing fat-splitting enzymes the rice oil decomposes very rapidly.

Another method of producing rice oil would be, of course, to extract the bran with solvents. According to Fraps[24] a plant was erected at Crowley, Louisiana, years ago for the purpose of extracting the fatty oil from rice bran. The importance of vitamins and the vitamin content of rice oil were not known at that time. The venture was not successful.

The decomposition (hydrolysis) of rice oil will be taken up later in connection with the deterioration of rice bran, and the vitamins in rice oil will be considered in the discussion of vitamins in rice bran.

[24] Texas Agr. Exp. Sta. Bull. 191 (1916) 36.

Kimm and Noguchi[25] made a qualitative investigation of the fatty oil in the embryo of the rice grain. They found that the embryo oil contains oleic, linolic, myristic, palmitic, stearic, and arachidic acids. As these compounds are also contained in the rice-bran oil the composition of the embryo oil resembles that of the rice oil in rice bran.

VITAMINS IN RICE BRAN

Rice bran contains the water-soluble vitamin B_1, which is the antineuritic vitamin that prevents polyneuritis in pigeons and beriberi in humans. The rice oil (fats) in rice bran contains the fat-soluble vitamins A and E. When irradiated, the rice oil also contains vitamin D.

Vitamin B_1.—The effects of feeding rice bran to pigeons ill with polyneuritis are shown very clearly by the photographs in Plate 9. A pigeon was fed by Dr. A. J. Hermano, of the Bureau of Science, on a ration deficient in vitamin B_1 until it developed polyneuritis (fig. 1). When given 0.5 gram of rice bran the pigeon recovered in one day and became normal (fig. 2).

Vitamin B_1 appears to be quite resistant to heat. We heated rice bran at a temperature of 105°C., for three hours. Doctor Hermano found that this heated bran cured pigeons of polyneuritis just as easily and quickly as the fresh bran.

McCollum and Simmonds[26] state that Jansen examined unhulled rice which had been stored for 100 years and found the rice had lost little or none of its antiberiberi property (vitamin B_1). From this it appears that the hull serves as an excellent protection for the vitamins contained in the rice kernel. Moreover vitamin B_1, under the proper conditions, has excellent keeping properties.

Kondo and Okamura[27] kept unpolished rice in sealed tin cans for several years and found the rice was not attacked by insects and there was little change in the physical and chemical properties.

Concerning the vitamin B complex Dutcher[28] says:

> Considerable work has been done to show that the vitamin B complex may consist of five or more fractions. The existence of the antineuritic fractions, B_1 has been established definitely and vitamin B_2 is recognized as

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[25] Scientific Papers of the Institute of Physical and Chemical Research, Tokyo 21 (1933) 4.

[26] The Newer Knowledge of Nutrition (1929) 116.

[27] Journ. Sci. Agr. Soc. Japan (1929) 183.

[28] Journ. Chem. Ed. 9 (1932) 1366.

a definite entity. These vitamins are also known, in this country, as B and G respectively. Eddy and co-workers contend that a third factor (B_3) is necessary for growth in pigeons, while Miss Reader of London believes that there is a fourth fraction of the old B complex which is necessary for normal growth in the rat. Miss Chick, also of London, is of the opinion that she has obtained evidence that a fifth fraction exists which is necessary for rat growth and which differs from B_4 in stability.

Windaus and co-workers have just announced the isolation of the antineuritic fraction (B or B_1) in crystalline form. Using modifications of the methods used by Jansen and Donath, Seidell and Peters, two types of crystalline products were isolated, one as the hydrochloride and one as the picrolonate. He ascribes the tentative formula, $C_{12}H_{17}N_3OS$, to this highly potent crystalline product. This compound was active in daily doses of from 2 to 4 gamma (2/1000 to 4/1000 of a milligram). The most potent preparations reported previously were those of Jansen and Donath, which were active in doses of from 7 to 9 gamma daily.

Rice-bran (*tikitiki*) *extract.*—For a number of years the Bureau of Science has been making an extract of rice bran (tikitiki extract) which contains vitamin B_1 and is used extensively for the cure of infantile beriberi. During the year 1931, 50,974 bottles of tikitiki extract with a sales value of 35,681.80 pesos were prepared. Of this number, 4,087 valued at 2,860.90 pesos were sold and 46,887 bottles with a sales value of 32,820.90 pesos were furnished to the Office of the Public Welfare Commissioner for free distribution.

The present method [29] used by the Bureau of Science for making rice bran (tikitiki) extract is indicated by the following outline:

1. Select a good grade of rice bran. This is ascertained by making an ether extract of the bran to determine the amount of fat it contains. This should be about 20 per cent calculated on a moisture free basis. If the fat content is much lower than this it indicates that the bran contains ground rice hulls or other foreign matter which does not contain any fat or vitamins; or perhaps the bran has deteriorated due to attacks of insects.

2. Mix the rice bran (50 kilos) with 25 per cent ethyl, or grain, alcohol (150 liters) and allow the mixture to stand, with occasional stirring, for twenty-four hours.

Vitamin B_1 is very soluble in water. The alcohol which is added serves to prevent fermentation of the vegetable matter in the bran.

3. Pour off the clear liquid and pass the sediment through the press.

4. Combine the liquids obtained in step 3 and evaporate to a syrupy consistency under 1 centimeter pressure with maximum temperature of 75° C.

5. Add 95 per cent alcohol to residue in step 4 to precipitate inactive gummy substances.

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[29] Wells, A. H., Philip. Journ. Sci. 19 (1921) 67.

6. Allow the gummy substances to settle for about twenty-four hours then decant off the supernatant liquid.

7. Evaporate the alcoholic solution with precautions observed in step 4 till the specific gravity of the syrup is brought to 1.32 at 28.5° C., which is about the usual temperature of the factory evaporating room.

8. This syrup is then passed through the supercentrifuge, heated to 80° C., and bottled immediately while hot. After sealing the stoppers with sealing wax the bottles are pasteurized at 62° C., for about a half hour.

This preparation is the finished product which is now ready to be used as a medicine for beriberi.

Mr. F. M. Yenko, who has charge of the tikitiki-extract plant in the Bureau of Science, finds that the yield of tikitiki extract from rice bran varies considerably depending upon the quality of the bran used in making the extract. A sack (50 kilos) of very high-grade bran may yield as much as 75 bottles (50 cubic centimeters each) of standard extract. A sack of low-grade bran, which contains a considerable quantity of broken rice kernels and rice hulls, may give only about 45 bottles. By selecting from a shipment only those sacks which contain bran of good quality rather high average yields of extract may be obtained. During the year 1932 Mr. Yenko obtained an average monthly production of 69 bottles of extract from one sack of bran. At this rate of production the potency of 1 cubic centimeter of extract is about equivalent to that of 14.5 grams of high-grade rice bran.

The Bureau of Science sells a 50-cubic-centimeter bottle of extract for 70 centavos (Philippine currency) or 35 cents (U. S. currency). The mail or freight charges are extra.

Hermano[30] standardized this extract and found that when 0.2 cubic centimeter is added daily to a basal ration deficient in vitamin B_1 the ration then contains sufficient vitamin B_1 to support a growing rat. Pigeons which had contracted polyneuritis were cured in one day when given an aqueous solution containing 0.0175 gram of the pure extract. In these experiments the pigeons were kept in cages which were covered with fine-mesh wire to prevent access of the flies known as *Pseudolyncha maura*. These flies transmit to pigeons a blood disease (*Haemoproteus columbae*) which may become so severe as to prove fatal.

Experiments were also made by Doctor Hermano to determine the relative potency of the standard tikitiki extract as compared with activated clay secured from the Bureau of Chemistry and

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[30] Philip. Journ. Sci. (in press).

Soils in Washington. This activated clay serves as an international standard for vitamin B_1. It has a concentration such that 10 milligrams are equivalent to one unit of vitamin B_1. A unit is that amount of vitamin B_1 which, when fed as a daily allowance, gives a weekly increase of 3 grams in the weight of an albino rat during an experimental period of four to eight weeks. Experiments in curing pigeons of polyneuritis showed that 10 milligrams of activated clay (1 unit) gave the same results as 17.5 milligrams of standard tikitiki extract.

In Table 15 is given the analysis of an average sample of standard tikitiki extract made in the Bureau of Science.

TABLE 15.—*Analysis of standard rice bran (tikitiki) extract made in the Bureau of Science.*

Constituent.	Composition. Per cent.
Total solids	70.37
Phosphorus as P_2O_5	1.68
Ash	3.54
Reducing sugars before inversion	28.35
Reducing sugars after inversion	29.99
Nonreducing sugars	1.27
Nitrogen	1.21
Alkalinity of ash in 100 grams tikitiki extract (gram KOH)	0.34
Qualitative analysis of ash for basic and acidic radicals.	Ca, Mg, K, Na, Cl, and S.
Specific gravity of extract at 27.5° C.	1.3189

The standard rice bran extract made in the Bureau of Science is an extract of high quality which contains no gums as these are removed, at extra expense, in the process of manufacture. As shown by the standardization tests of Doctor Hermano this preparation is also a very potent extract.

Vitamin A (fat-soluble) in rice bran.—McCarrison[31] found in unhulled rice vitamin A which prevents eye afflictions. Hermano[32] fed albino rats on a ration deficient in vitamin A until they developed general ill health and the eye disease known as xerophthalmia. The basal ration was then supplemented daily with 0.2 cubic centimeter of the fatty oil contained in rice bran. After one week the eye disease was cured and in one more week the rats had recovered their health and were again normal.

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[31] McCollum, E. V., and N. Simmonds, The Newer Knowledge of Nutrition (1929) 115.

[32] Philip. Journ. Sci. (in press).

Plate 9, fig. 3, shows an albino rat in bad health and suffering from vitamin A deficiency. Fig. 4 shows the same rat recovered and in normal condition. The fatty oil used in these experiments was an ether extract of rice bran. The extract was heated in an air bath at a temperature of 105° C., for three hours to remove traces of ether. Evidently heating the fatty oil did not destroy the vitamin.

Vitamin E (fat-soluble) in rice bran.—Hermano[33] tested the fatty oil contained in rice bran and found it gave positive results for vitamin E (fat-soluble) which prevents sterility. Concerning his experiments he states:

> Six pairs of healthy rats were mated in six different cages. They were fed with the basal ration deficient in vitamin E. Three pairs of the rats, 1, 2, 34, 35, 36, and 37, were fed with the basal ration deficient in vitamin E for about three to four months, and no litters were produced. After an interval of time as indicated by the point x (text fig. 1, charts I and VII) the basal ration was supplemented daily with 0.2 cubic centimeter of the ether extract of crude tikitiki (rice bran). The results of the addition were significant in that these three pairs produced seventeen young. The other three pairs, rats, 3, 4, 25, 26, 27, and 28, continued to be fed with basal ration deficient in vitamin E; and, though they appeared to be healthy and mature, they produced no litters (text fig. 2, charts II and VI). . . . The ether extract from crude rice bran possesses the antisterility property, vitamin E.

Vitamin D in irradiated rice oil.—In making Japanese saké wine the saké cake that remains as a residue contains some rice oil. Takahashi and Lim[34] extracted the rice oil from saké cake. The unsaponifiable matter in the rice oil was then removed and from this unsaponifiable matter they isolated a crystallized sterol which melted at 137° C. These sterol crystals were then exposed to ultraviolet light (irradiated). Takahashi and Lim found that these irradiated sterol crystals were antirachitic and, when fed to albino rats, could cure and prevent rickets. Evidently the sterol crystals, when irradiated, developed the antirachitic vitamin D.

Rice oil contains about 4 per cent of unsaponifiable matter (Table 13) which is a comparatively large amount. Since unsaponifiable matter consists largely of sterols it would seem quite likely that vitamin D is either contained in rice oil or may be developed in the oil by irradiation.

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[33] Philip. Journ. Sci. 41 (1930) 387.

[34] Journ. Agri. Chem. Soc. Japan 6 (1930) 109.

Hermano[35] tested rice oil for vitamin D and found it gave negative results. He then exposed the oil for fifteen minutes to ultraviolet light and tested the irradiated oil. Albino rats were fed for about a month on a basal ration deficient in vitamin D until the rats developed symptoms of rickets. The joints in the hind legs became somewhat swollen and the rats moved rather slowly. The basal ration was then supplemented daily with an olive oil solution containing 0.003 gram of irradiated rice oil. After three weeks the rats became quite lively, walked well and the leg swellings disappeared. The rats were then killed and the tibia bones in the hind legs cleaned, treated properly, and photographed. The photographs showed considerable calcification in the bones. Photographs of the tibia bones from rats fed on the same ration, except that cod-liver oil was used in place of rice oil, showed somewhat more calcification. Perhaps if the rice oil had been irradiated somewhat longer it would have given results as good as the cod-liver oil. For when the rice oil was irradiated for periods of only 5 and 10 minutes the results were not as good as when it was irradiated for 15 minutes.

Chicken perosis.—When used in a uniform diet for growing chickens, as pointed out in a note published recently,[36] rice bran appears to be superior to wheat as preventative of perosis (deforming leg weakness) in chickens.

> In the fall of 1929 the animal husbandry division of the Bureau of Animal Industry and the departments of poultry husbandry of several Southern and Southwestern state agricultural experiment stations organized an informal coöperative project for the purpose of comparing, on a weight-for-weight basis, different feeding stuffs when included in a so-called "uniform" diet for growing chickens. During the spring and summer of 1930 the following experiment stations used the "uniform" diet in some of their feeding experiments with the growing chicks; Kansas, Louisiana, New Mexico, Missouri, Texas, the U. S. Poultry Experiment Station, Glendale, Arizona, and the U. S. Animal Husbandry Experiment Farm, Beltsville, Maryland.
>
> Several of the stations reported that when the "uniform" diet was fed to chicks kept in confinement a high percentage of them became afflicted with perosis (deforming leg weakness). One of the writers (W. M. G.), observed, however, that when 10 and 20 per cent of rice bran replaced equivalent amounts of wheat in the "uniform" diet, no cases of perosis occurred. . . .

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[35] Philip. Journ. Sci. (in press).

[36] Science 74 (1931) 249.

Perosis, or deforming leg weakness, in chickens is a condition of dietary origin, in which the legs become deformed in various ways.

The superiority of the rice bran as reported in these experiments is quite likely due to some vitamin contained in it.

Commercial importance of vitamins in rice oil.—Rice oil contains the fat-soluble vitamins A and E; and, when irradiated, vitamin D is developed in the oil. Should the vitamin D content of rice oil be increased, with sufficient irradiation, to that of cod-liver oil then the rice oil may become an important nutritive substance. Possibly it could be used as a substitute for cod-liver oil. Rice oil has a bland, fatty taste and in this respect the oil is certainly more agreeable to take than cod-liver oil.

In the United States the use of vegetable oils, particularly coconut oil, in making margarine has increased very considerably in recent years. According to Snodgrass:[37]

> Since the war the vegetable fats, and in particular coconut oil, have continued to grow in popularity in this country until now the ratio of animal to vegetable fats used in margarine is almost the reverse of what it was before the war. Approximately 60 per cent of the ingredients are now of vegetable origin, and only 40 per cent animal fats. Coconut oil is far and away the most important single ingredient, . . . In 1925–26 more of it was used than of all the animal fats together and over a period of several years it has been more important than oleo oil and neutral lard combined. The only other vegetable fat used in appreciable quantities is cottonseed oil.

Coconut oil does not contain the fat-soluble vitamins[38] A, D, and E. Since rice oil contains the fat-soluble vitamins A and E it might serve as an important product for use in the margarine industry as the rice oil would supply the vitamins which are not contained in the coconut oil. Mixtures of coconut and rice oils should make a margarine more like natural butter than when coconut oil alone is used.

In producing rice oil for commercial purposes either bran fresh from the polisher may be used or, as explained later, bran which has been heated and properly preserved. The rice oil may be extracted from the bran by means of hot coconut oil. The rice oil may also be produced by expressing mixtures of rice bran and expeller copra cake or by expressing the rice bran alone.

Data on the colors of mixtures of coconut and rice oils are given in Table 16.

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[37] Food Research Institute, Stanford University, California, Fats and Oils Studies, No. 2 (1928) 105.

[38] Sherman, H. C., and S. L. Smith, The vitamins (1931) 270, 296, 329, and 341.

TABLE 16.—*Color of mixtures of coconut and rice oils.*[a]

Sample.	Mixture.		Color.	
	Coconut oil.	Rice oil.	Red.	Yellow.
	Per cent.	*Per cent.*		
1	100	----------	0.1	0.6
2	95	5	1.7	17.0
3	90	10	2.5	57.0
4	80	20	4.9	141.0
1-A	100	----------	2.1	15.0
2-A	95	5	3.0	42.0
3-A	90	10	4.1	87.0
4-A	80	20	6.5	165.0

[a] In these tests the same sample of rice oil was used for making mixtures with the coconut oil samples 1 and 1-A.

Rice oil is very much darker in color than coconut oil. When rice oil is mixed with coconut oil in various proportions the color of the mixed oil is darker than that of the coconut oil alone. The color of the coconut oil and also that of the mixed oils was determined by means of a Wesson model, cabinet-type colorimeter made by the Emil Greiner Co.

For our tests we used two different samples of coconut oil. One sample (No. 1) was a water-white oil which had been decolorized[39] by treating successively with Kieselguhr, vegetable charcoal (suchar), and talcum powder. The other sample (No. 1-A) was a high-grade, light yellow, commercial oil. In determining the color of the coconut oil alone we followed the procedure adopted by the Conference of Coconut Oil Manufacturers of the Philippines (1924).

> All samples will be read to a yellow base to be determined by adding the two whole red units, within whose limits the sample falls, and multiplying same by 3.

As this procedure does not apply to mixtures of rice and coconut oils we simply used enough of the standard glass plate colors (red and yellow) to match the color of the mixed oil.

The results (Table 16) show that, as the percentage of rice oil in the mixture increases, there is a much greater increase in the yellow hue than in the red. In making margarine[40] this should be an advantage. For by incorporating rice oil with the other emulsified ingredients there is a tendency for the resulting margarine to be somewhat colored by a natural coloring matter.

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[39] Cruz, A. O., and A. P. West, Philip. Journ. Sci. 41 (1930) 53.

[40] Clayton, W., Margarine (1920) 35. Snodgrass, K., Margarine as a Butter Substitute (1930) 120.

PROTEINS IN RICE BRAN

Proteins are complex substances containing combinations of amino acids. Numerous researches have been carried out to determine the biological value of the proteins contained in various foods of animal or vegetable origin. Experiments in feeding animals, usually albino rats, have shown that some proteins (meat proteins) contain in their make-up certain amino acids which are necessary for the normal maintenance and growth of the animal body. The most important of these amino acids are generally believed to be histidine, lysine, tryptophane, and cystine. The biological value of a protein seems to depend, in general, upon the amount of these particular amino acids which are contained in the protein. Inferior proteins are deficient in these important amino acids necessary for maintenance and growth.

Osborne, Van Slyke, Leavenworth, and Vinograd[41] investigated the hydrolytic products of the protein of the rice kernel. They summarized their results as follows:

> The partition of nitrogen among the products of hydrolysis of oryzenin, the chief protein of the endosperm of rice, was determined by the Van Slyke method. Compared with the endosperm proteins of wheat or maize, the protein of rice yields relatively much of each of the basic amino acids, arginine, and lysine, and comparatively little ammonia and non-amino nitrogen. In its general amino-acid make-up it more nearly resembles the majority of the proteins of animal tissues than do the proteins of maize or wheat. This may explain the extensive use of rice as an almost exclusive diet in spite of its low protein content.

In the process of polishing rice the embryo goes with the rice bran. Hamada[42] investigated a sample of rice embryo containing about 70 to 80 per cent of pure embryo. He isolated the protein, oryzenin, from the rice embryo and by hydrolysis estimated the amino nitrogen contained in it. The following results were obtained:

	Per cent.
Nitrogen:	
Monoamino	54.44
Diamino	35.68

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[41] Journ. Biol. Chem. 22 (1915) 274.

[42] Journ. Chem. Soc. Japan 44 (1923) 68. Scientific Papers of the Institute of Physical and Chemical Research, Tokyo 4 No. 46 (1925) 22.

Diamino nitrogen as:	Per cent.
Arginine	20.04
Histidine	5.72
Lysine	9.12
Cystine	0.68

As shown by these data the protein of the rice embryo contains the important amino acids, histidine, lysine, and cystine. Since rice bran contains the rice embryo these amino acids are therefore contained in the proteins of the rice bran.

From his experiments Hamada concluded that the protein of the rice embryo has a high biological value comparing favorably with meat proteins. Subsequent feeding experiments proved this.

Rice bran contains not only the rice embryo but also some of the rice endosperm (white rice) that is, the interior part of the rice kernel. Jones and Gersdorff [43] investigated the proteins in white (polished) rice and also the proteins in commercial rice bran. They found that the proteins in the white (polished) rice contain the amino acids, histidine, lysine, tryptophane, cystine, arginine, and tyrosine. The proteins in the rice bran were tested for the amino acids, tryptophane, cystine and tyrosine which were found to be present.

As a result of these various investigations it appears that the proteins in rice bran contain the important amino acids (histidine, lysine, tryptophane, and cystine) necessary for maintenance and growth.

Dr. J. Marañon,[44] of the Bureau of Science, investigated the nitrogen distribution in Philippine rice bran by means of Hausmann's method as modified by Osborne.[45] The results are recorded in Tables 17 and 18. He found that the protein nitrogen is about 8 times the nonprotein (Table 17). Investigation of nonprotein nitrogen showed that it contains mostly nonbasic nitrogen. The protein nitrogen consists largely of nonbasic nitrogen but also has a considerable amount of basic nitrogen. The data for the protein nitrogen distribution were calculated by the difference between the results of the nitrogen distribution after hydrolysis (Table 18) and the values of the hydrolytic nonprotein products (Table 17). These results agree, in general, with those obtained by Hamada for he found in the protein of the rice embryo more monoamino (nonbasic) nitrogen than diamino (basic) nitrogen.

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[43] Journ. Biol. Chem. 74 (1927) 415. Mitchell and Hamilton, The Biochemistry of the Amino Acids (1929) 181.

[44] Philip. Journ. Sci. (in press).

[45] Gortner, R. A., Outlines of Biochemistry (1929) 331.

TABLE 17.—*Nitrogen distribution in Philippine rice bran.*

Kind of nitrogen.	Rice bran.		Results calculated on basis of total nitrogen.[a]
	Air dried.	Moisture free.	
	Per cent.	*Per cent.*	*Per cent.*
Nonprotein	0.229	0.259	11.439
(Water soluble)	(0.391)	(0.442)	(19.523)
Protein[b]	1.771	2.005	88.561
Total	2.000	2.264	100.000
Nonprotein nitrogen:			
Acid amide	0.034	0.038	1.678
Humin	0.019	0.021	0.927
Basic	0.027	0.031	1.369
Nonbasic	0.149	0.169	7.465
Total	0.229	0.259	11.439
Protein nitrogen (calculated):			
Acid amide	0.154	0.174	7.685
Humin	0.049	0.055	2.429
Basic	0.300	0.340	15.018
Nonbasic	1.212	1.372	60.601
Undetermined	0.056	0.064	2.828
Total	1.771	2.005	88.561

[a] Calculated on the moisture-free sample containing 2.264 per cent nitrogen.

[b] The protein nitrogen is the difference between the total nitrogen and the nonprotein nitrogen.

TABLE 18.—*Distribution of rice-bran nitrogen after acid hydrolysis.*

Kind of nitrogen.	Rice bran.		Results calculated on basis of total nitrogen.[a]
	Air dried.	Moisture free.	
	Per cent.	*Per cent.*	*Per cent.*
Acid amide	0.188	0.212	9.364
Humin	0.068	0.076	3.357
Basic	0.327	0.371	16.387
Nonbasic	1.361	1.541	68.065
Undetermined	0.056	0.064	2.827
Total	2.000	2.264	100.000

[a] Calculated on the moisture-free sample containing 2.264 per cent nitrogen.

The comparative nutritive value of the proteins contained in rice bran and soy beans has been investigated by Mitchell and

Villegas.[46] They determined the actual digestible nitrogen of the protein rations fed. On a 10 per cent protein ration the results seemed to show that there was no distinct difference between the protein of rice bran and soy beans. The protein of soy beans, unlike that of other vegetables, is similar to both meat and milk protein and seems to fulfill all physiologic requirements.[47] It would appear that the proteins in rice bran have a high biological value and, like soy-bean protein, compare favorably with meat proteins.

RICE BRAN LACKS GLUTEN

Concerning gluten Thorpe[48] states:

> Wheaten flour differs from that of all other cereals in that after it has been made into a dough with a little water, it is possible to wash out the starch, leaving a sticky adhesive brown or greyish-brown residue which consists mainly of protein. This is crude gluten: on drying it in a water-oven, a hard, brittle horny mass, not unlike glue, results, which has lost its power of becoming plastic when wetted, and strongly adheres to the substance on which it rests. At a higher temperature, the wet gluten expands greatly until the expansive force ruptures its vesicles.
>
> The flour of other cereals when washed in a similar way entirely disintegrates, leaving no protein residue. The physical properties of wheaten dough depend almost entirely on the gluten, which acts as a mechanical agency for binding the particles of starch and for entangling the carbon dioxide gas produced by the fermentation: in the oven, this gas expands, causing the dough to rise and the gluten to remain distended until the heat fixes it.

Tadokoro[49] studied the chemical properties of glutinous and nonglutinous rice and found they were quite different in various respects.

Rice does not contain gluten. The so-called glutinous rices contain a kind of sticky substance instead of true gluten.[50] When used alone rice bran, lacking gluten, does not make bread which will rise. However, when rice bran is mixed with wheat flour the combination makes a bread which rises nicely and has a good texture.

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[46] Journ. Dairy Sci. 6 (1923) 222.

[47] Daniels, A. L., and N. B. Nichols, Journ. Biol. Chem. 32 (1917) 95. Osborne, T. B., and L. B. Mendel, Journ. Biol. Chem. 32 (1917) 375.

[48] A Dictionary of Applied Chemistry 3 (1928) 427.

[49] Journal College of Agriculture, Hokkaido Imperial University, Sapporo, Japan 16 (1926) 91.

[50] Copeland, E. B., Rice (1924) 326.

UNBALANCED MINERAL CONSTITUENTS

Kintner and Holt[51] studied equine osteomalacia (bone weakening) in the Philippines and found that the prevention of this disease depends on the feeding of a ration properly balanced in the important mineral constituents calcium oxide and phosphorus pentoxide. The ration should be so balanced that the calcium oxide-phosphorus pentoxide intake ratio is between 1:1 and 1:1.8. Where there is a deficiency in one of these mineral factors this balance may be attained by adding to the ration the required amount of the proper constituent.

Rice bran has a rather high ash content, containing about 10 per cent (Table 20). Analysis of the ash for calcium and phosphorus has been made by Mr. M. Tirona, formerly of the Bureau of Science. The following results were obtained:

	Per cent.
Phosphorus pentoxide (P_2O_5)	5.09
Calcium oxide (CaO)	0.06

As shown by these data the ratio between the calcium oxide and the phosphorus pentoxide is not well balanced as the percentage of phosphorus pentoxide is quite high in comparison with the percentage of lime, which is very low. The composition of the bran, in this respect, resembles that of polished rice which also contains a relatively high content of phosphorus as compared to lime. In feeding stock this unbalanced ratio could be corrected, in accordance with the suggestions of Kintner and Holt, by adding the proper amount of calcareous constituents to a rice-bran ration or to the drinking water.

According to Sherman[52] 0.45 gram of calcium (0.63 gram CaO) and 0.88 gram phosphorus (2.02 grams P_2O_5) fill the actual daily requirement for adult humans but this represents the minimum of actual need rather than the normal allowance. He considers that the normal allowance for phosphorus should be 50 per cent above the average minimum while for calcium it should be even greater. He estimates the optimum allowance to be 0.70 gram calcium (1.0 gram CaO) and 1.32 grams phosphorus (3.0 grams P_2O_5). The optimum calcium oxide-phosphorus pentoxide ratio is 1.0 : 3.0 according to these data.

Concerning the use of rice bran as an ingredient of human food this unbalanced calcium-phosphorus ratio is not a serious matter for people who live on a mixed diet. For this ratio could be balanced to a considerable extent by including suitable vegetables in the diet; that is, vegetables which have a high ash content and a relatively large amount of calcareous matter in the ash.

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[51] Philip. Journ. Sci. 49 (1932) 75.

[52] Chemistry of Food and Nutrition (1932) 291, 298, 512.

Marañon[53] has recently investigated the mineral constituents of a considerable number of edible Philippine plants. His results for a few of the very common vegetables sold in the local markets are given in Table 19.

As shown by the data (Table 19) these vegetables contain considerably more calcareous matter than the phosphoric ingredient. This unbalanced mineral ratio is just the opposite of that in rice bran. The addition of these vegetables to a ration containing rice bran would tend to balance the calcium-phosphorus ratio in the bran.

NUTRITIVE VALUE OF RICE BRAN

Rice bran as a cattle food.—Rice bran should have a comparatively high food value since it contains vitamins, proteins, and fats. These are the most nutritious constituents of the rice grain.

In Louisiana, Texas, and elsewhere in the southern United States rice bran (polishings) has been used in feeding experiments[54] with cattle. The results showed that fresh rice bran, which has a sweet odor, is somewhat better than corn or corn meal. However, if the bran becomes rancid, due to decomposition of the fat contained in it, the cattle do not like it. Cattle also do not care for rice bran that has been mixed with any considerable quantity of rice hulls. It is generally believed that bran which contains rice hulls is not suitable for use as an edible product.

Lush and Hale[55] fed cows with a mixture consisting of fresh rice bran (90 per cent) and cottonseed meal (10 per cent) and found that the ration had no effect upon the flavor of milk given by the cows. They concluded that fresh, non-rancid rice bran is a desirable and economical dairy food.

In the Philippines rice bran has served as cattle food for a number of years. When bran that is not fresh is used for feeding horses an old local custom is to mix the bran with molasses to neutralize the stale taste.

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[53] Philip. Journ. Sci. (in press).

[54] U. S. Dept. Agr. Farmers' Bull. 412 (1910) 18.

[55] Texas Agr. Exp. Sta. Bull. 352 (1927) 22.

TABLE 19.—*Some common Philippine vegetables which have a comparatively high calcium and low phosphorus content.*[a]

Name of plant.		Part of plant used.	Ash.	Phosphorus (P_2O_5).	Calcium (CaO).	Ratio CaO:P_2O_5.
Scientific.	Common.					
			Per cent.	*Per cent.*	*Per cent.*	
Amaranthus paniculatus Linn.	Kudiapa	Leaves and tops	18.69	1.40	3.67	1 : 0.4
Amaranthus viridis Linn.	Kolitis (kalunai)	Leaves	19.64	1.99	3.63	1 : 0.5
Apium graveolens Linn.	Celery (kinchai)	Leaves and petioles	14.71	1.12	2.45	1 : 0.5
Basella rubra Linn.	Ceylon spinach (alugbati)	Leaves and tops	16.08	1.51	3.33	1 : 0.5
Beta vulgaris Mog.	Beet (remolacha)	Leaves	22.40	1.27	3.17	1 : 0.4
Beta vulgaris Linn. var. *cicla* Linn.	Swiss chard	do.	20.27	0.73	3.14	1 : 0.2
Brassica chinensis Linn.	Petsai (pechai)	Leaves and petioles	18.20	1.74	4.65	1 : 0.4
Brassica integrifolia (West) O. E. Schulz	Chinese mustard	do.	18.94	1.90	3.30	1 : 0.6
Brassica oleracea Linn. var. *acephala* DC	Koles (kales)	Leaves	16.54	1.67	5.04	1 : 0.3
Capsicum frutescens Linn.	Bird pepper (sili)	do.	14.45	1.11	2.27	1 : 0.5
Colocasia esculentum (Linn.) Schott	Taro (gabi)	do.	13.51	1.19	2.22	1 : 0.5
Coriandrum sativum Linn.	Coriander (ongsoy)	Leaves and petioles	10.69	1.16	2.56	1 : 0.5
Lactuca sativa Linn.	Lettuce (lechugas)	Leaves	17.55	1.60	2.78	1 : 0.6
Momordica charantia Linn.	Amargoso (ampalaya)	do.	18.77	1.37	4.36	1 : 0.3
Petroselium hortense Hoffm.	Parsley (perejil)	do.	15.90	1.29	2.79	1 : 0.5
Plantago major (L.) var. *asiatica* Decne.	Japanese plantain	do.	15.08	1.07	3.86	1 : 0.3
Psophocarpus tetragonolobus (Linn.) DC	Seguidillas	Young pods	7.74	0.24	1.37	1 : 0.2
Solanum nigrum Linn.	Amantec	Leaves	12.08	1.23	3.68	1 : 0.3

[a] The percentages were calculated on the moisture-free sample.

Rice bran has a higher food value than ordinary hydraulic copra cake, which contains about 5 per cent of coconut oil. This is shown by the data given in Table 20. In calculating these food values one gram of carbohydrates, or proteins, was considered as giving 4.1 calories and one gram of fats 9.3 calories.

TABLE 20.—*Composition and food value of Philippine rice bran compared with hydraulic copra cake.*

Constituent.	Rice bran.[a]	Hydraulic copra cake.[b]	Mixture of equal parts of rice bran and hydraulic copra cake.
	Per cent.	*Per cent.*	*Per cent.*
Moisture	10.04	5.38	7.71
Fat	19.08	5.00	12.04
Protein	11.27	19.90	15.59
Ash	10.32	5.90	8.11
Crude fiber	8.67	9.50	9.08
Carbohydrates (by difference)	40.62	54.32	47.47
Total	100.00	100.00	100.00
Calories per kilo	3,902	3,508	3,705

[a] Analysis made by Mr. H. Taguibao, of the Bureau of Science.

[b] West, A. P., and W. H. Brown, Bull. Philip. Bur. Forestry **20** (1920) 100.

Copra cake is used considerably as cattle food and some buyers prefer a cake which has a somewhat higher fat content than is ordinarily contained in hydraulic copra cake. A mixture of hydraulic copra cake and rice bran in equal proportions gives a combination that has a higher food value than the copra cake alone, for it contains not only sufficient proteins and carbohydrates but more fat. Furthermore, the combination has the fat-soluble vitamins A and E, which are not contained in copra cake. For a cattle food this is a decided advantage since it tends to enrich the milk of the cattle in fat-soluble vitamins.

Rice bran as a human food.—Table 21 gives the composition and food value of Philippine rice bran (hambas variety) compared with wheat bran and flour.

As shown by the data (Table 21) rice bran has a much higher food value (calories) than either the wheat bran or the flours. This is due to the fact that the rice bran has a much higher fat content than the wheat bran or flours although the protein and carbohydrate contents are lower.

Recently the Bureau of Science has taken steps to popularize the use of rice bran as a human food. At the industrial exhibition held recently in Manila the Bureau gave an interesting display of bread, cakes, and other bakery products made from rice bran. Miss Orosa has published a popular bulletin[56] on rice bran as a health food and how to cook it. This bulletin gives recipes for making rice-bran biscuits, fritters, croquettes, pudding, cookies, and many other tasty foods.

TABLE 21.—*Composition and food value of Philippine rice bran (hambas) compared with wheat bran and flour.*

Constituent.	Composition.				
	Bran.		Flour.		Mixture of rice bran (1 part) and wheat flour (3 parts).
	Rice.[a]	Wheat.[b]	Graham.[b]	Wheat.[b]	
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	10.04	10.91	7.73	9.93	9.96
Fat	19.08	5.03	1.79	0.92	5.46
Protein	11.27	14.84	15.33	13.74	13.12
Ash	10.32	5.59	1.32	0.52	2.97
Crude fiber	8.67	5.98			[c]2.17
Carbohydrates (by difference)	40.62	57.65	73.83	74.89	66.32
Total	100.00	100.00	100.00	100.00	100.00
Calories per kilo	3,902	3,440	3,822	3,719	3,765

[a] Analysis made by Mr. H. Taguibao, of the Bureau of Science.

[b] Leach, A. E., and A. L. Winton, Food Inspection and Analysis (1920) 320 and 322.

[c] This figure is only approximately correct since the crude fiber was not determined in the Graham and wheat flours. One gram of carbohydrates or proteins was calculated as giving 4.1 calories and 1 gram of fats 9.3 calories.

Some people do not fancy the natural flavor of rice bran. For such people the flavor may be toned down considerably by diluting the bran with wheat flour. A mixture of wheat flour (3 parts) and rice bran (1 part) makes a good combination for bakery products such as bread and cakes. This combination has a food value (Table 21) higher than that of wheat flour.

Rice bran, when used alone, lacks gluten and does not make bread which will rise. The addition of wheat flour serves not only to dilute the bran but also to supply the gluten necessary for making bread.

The bran flavor may be still further neutralized or entirely disguised by using other characteristic flavors, such as ginger, cinnamon, or chocolate. Bran cookies made with these flavors are very tasty and since they contain vitamins they are quite nutritious.

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[56] Bu. Sci. Pop. Bull. 15 (1932).

Rice bran as a preventative of beriberi.—In the Philippines beriberi is a very common and fatal disease among the poorer classes who live on a diet that consists principally of polished rice and is deficient in vitamin B_1. The standard extract of rice bran (tikitiki extract), made in the Bureau of Science, is widely used and has given excellent results as a preventative or cure for beriberi.

According to Van Veen,[57] Jansen and Donath estimate that the amount of antineuritic vitamin B_1 contained in 30 grams of rice bran is probably more or less the quantity required for an adult per diem. This is just about equivalent to 11 level (not heaping) teaspoonfuls of bran or approximately 2 cubic centimeters of standard rice-bran extract (14.5 grams of high-grade bran make 1 cubic centimeter of extract).

In the Philippines more than 111,000 tons of fine rice bran are produced annually as a rice-mill by-product. Estimating the population of the Islands at 13,000,000, this is sufficient to supply each person daily with about 23.3 grams of fine rice bran. People who live on a mixed diet do not require the bran for its medicinal value so the annual production of rice bran is probably about sufficient for all the people who really need it and for others who would benefit by using it.

In a very few localities in the Philippines the people have for years been used to eating a kind of cake made from a mixture containing some fresh rice bran. If this use of rice bran as a human food could be popularized and people all over the Islands become accustomed to eating bakery products or other foods containing rice bran, then deaths from beriberi would be a rarity. It would not be necessary for the poorer classes to take extract of rice bran as a preventative or cure for beriberi.

DETERIORATION OF RICE BRAN

Insect infestation.—When rice bran, fresh from the polisher, is allowed to stand for a day or so the bran becomes infested with insects. Unhulled rice grains frequently carry insect eggs that have been deposited upon the grain in the field before the grain is brought to the mill. Again, insects breed freely in rice bran which accumulates about the mill. There is a Philippine ordinance which provides that rice mills shall be cleaned of all waste once a day but this regulation is not strictly enforced. We visited mills which were really very clean but there were others which presented quite a different appearance. In the Philippines, as in the United States and other countries, insect infestation is one of the important problems connected with the milling industry.

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[57] Mededeelingen Van Den Dienst Der Volksgezondheid in Nederlandsch-Indie 20 II (1931) 1.

W. Schultze,[58] formerly entomologist of the Bureau of Science, has identified the following insects which infest unpolished rice:

Rice weevil, *Sitophilus oryzae* Linn.
Rice moth, *Corcyra cephalonica* Staint.
Rust-red flour beetle, *Tribolium ferrugineum* Fabr.
Granary weevil, *Sitophilus granarius* Linn.

Vedder and Feliciano [59] found that when these insects infest unpolished rice they prefer to eat away the most nutritious part of the grain. This is the external layer or that portion removed during the polishing process. These insects thus convert an unpolished rice into a polished rice. Samples of unpolished rice which were infested with insects for one hundred days were analyzed before and after the period of infestation. The results showed a very decided decrease in the percentage of fat and phosphorus pentoxide. Unpolished rice, which before the infestation was beriberi-preventing, thus lost this medicinal property.

Heat for controlling insects in flour mills and grain elevators has been used considerably in the United States. Dean,[60] who investigated this problem, found that a temperature of only 118° to 125° F., (48° to 51.5° C.), maintained for several hours to enable the heat to penetrate all infested parts, will kill all insects and insect eggs. The heat, obtained from steam pipes, does not injure the grain and is more efficient than fumigation.

We found, as stated later, that insect infestation in rice bran may also be prevented by heat.

Decomposition of rice oil.—The deterioration of rice bran is not only caused by the ravages of insects but also by the decomposition of the fatty oil contained in the bran. Pure vegetable fats, or fatty oils, usually consist almost entirely of a mixture of glycerides of fatty acids. Rice oil, for instance, consists principally of the glycerides of oleic, linolic, and palmitic acids. Under certain conditions, such as the action of moisture and enzymes, these glycerides are gradually decomposed (hydrolyzed) and converted into glycerol and a mixture of free fatty acids. The free acids may then undergo oxidation and the fats acquire an unpleasant odor and taste, and become rancid. However, a high acid number is no indication of a rancid fat for rancid fats may contain either small or very large amounts of free fatty acids. According to Lewkowitsch[61] the initial phase of rancidity (hydrolysis) is accelerated by the action of enzymes. Fat-hydrolyzing enzymes occur in most, if not all, oleaginous seeds. The freshest vegetable oils and fats always contain at least minute quantities of free fatty acids. The formation of free fatty acids in vegetable oils is due to the action of moisture in the presence of enzymes (soluble ferments) which act as catalysts and accelerate the hydrolysis of the fats. Thus olein, $(C_{17}H_{33}COO)_3C_3H_5$, the fat which is the glyceride of oleic acid, when hydrolyzed yields glycerol, $C_3H_5(OH)_3$, and oleic acid, $C_{17}H_{33}COOH$.

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[58] Philip. Journ. Sci. **35** (1928) 382.

[59] Philip. Journ. Sci. **35** (1928) 383.

[60] Kansas Agr. Exp. Sta. Bull. **189** (1913).

$$(C_{17}H_{33}COO)_3C_3H_5 + 3HOH \rightarrow C_3H_5(OH)_3 + 3C_{17}H_{33}COOH.$$

For convenience it is usually customary to calculate the amount of the free fatty acids in vegetable oils simply as oleic acid.

At ordinary temperatures moisture alone is not effective in decomposing vegetable fatty oils (glycerides). According to Lewkowitsch:[62]

> At temperatures up to about 150° C., water does not attack glycerides but if the temperature be raised to 200° C., or more, the triglycerides are finally decomposed (hydrolyzed) into their proximate components, glycerol and fatty acids. . . . The hydrolysis thus produced at high temperatures is greatly accelerated if the action of the water is assisted by suitable chemical agents. If such agents are present, it is possible to reduce the temperature . . . the change may be brought about by water even at the ordinary temperature if naturally occurring ferments, such as lipase or steapsin, are intimately intermixed with the oils and fats.

Rice bran as it comes from the polisher has a fresh and somewhat sweet odor. If the bran is obtained from rice milled soon after the harvest the amount of free fatty acids in the fatty oil contained in the bran is usually very low. We found samples of bran that gave only 1.2 per cent of free fatty acids in the rice oil. Perhaps if the mill had been thoroughly cleaned before milling the grain the percentage of free fatty acids would have been even smaller. Samples of bran from grain which had been stored for some months gave a much higher percentage of free fatty acids in the rice oil ranging from about 2 to 6.5 per cent. From our results it would seem that, due to the action of moisture in the presence of enzymes, the fatty oil in the unhulled rice grain gradually decomposes to some extent when the grain is stored. Perhaps this is the reason that polished rice from freshly harvested grain has a better flavor than rice milled from grain that has been stored a long time. During the polishing process not all of the outer aleurone layer containing fats is removed from the rice kernel, for the polished rice still contains over 1 per cent of fat (Table 11). If the fats which remain with the polished rice are acid they may have a flavor which is not so agreeable as that of the pure glycerides (fats). Compared with other foods rice has relatively little flavor and so the presence of even a small amount of acid fat may, perhaps, affect very appreciably the flavor of polished rice.

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[61] Chemical Technology and Analysis of Oils, Fats, and Waxes 1 (1921) 50, 52 and 54.

[62] Chemical Technology and Analysis of Oils, Fats, and Waxes 1 (1921) 49 and 50.

The fatty oil in rice bran, fresh from the polisher, may contain only a very small percentage of free fatty acids but when the bran is allowed to stand there is a very rapid increase in the amount of free fatty acids contained in the fatty oil with a corresponding decrease in the amount of pure fat.

According to Browne[63] this rapid decomposition of rice oil is due to a fat-splitting enzyme (lipase). Excessive acidity has been observed in a few other vegetable oils, such as palm and olive, and has been found to be due to enzyme action.[64]

Concerning the production of palm oil in Africa Lewkowitsch[65] states:

> In consequence of the very crude mode of producing palm oil, causing it to remain for a considerable time in contact with fermentable vegetable tissue, hydrolysis rapidly sets in, so that the oil on reaching the coast contains already a notable amount of free fatty acids. Palm oil when shipped from the coast has at least 10–12 per cent of free fatty acids. The process of hydrolysis, once begun, continues in the barrels during the voyage, and in consequence thereof commercial palm oils, on arriving at their destination, contain frequently from 20 to 50 per cent, and even more, of

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[63] Journ. Am. Chem. Soc. 25 (1903) 948.

[64] Lewkowitsch, J., Chemical Technology and Analysis of Oils, Fats, and Waxes 2 (1922) 363.

[65] Chemical Technology and Analysis of Oils, Fats, and Waxes 2 (1922) 558.

free fatty acids. In such palm oils free glycerol is found. In old samples the hydrolysis may even reach completion, so that such palm oil practically consists of free fatty acids. The progress of hydrolysis can be observed even in oils kept in glass bottles. Thus a sample of Drewin oil, which had originally the acid value 41.8, showed after six (summer) months the acid value 70.1.

In the case of rice oil we have a condition somewhat similar to that of commercial palm oil. Rice bran as it comes from the polisher contains fatty oil in contact with fermentable vegetable tissue. The rice oil in the bran contains free fatty acids showing that hydrolysis of the oil has already started before milling the grain. The longer the oil is allowed to remain in contact with the vegetable tissue the greater will be the production of free fatty acids unless something is done to stop the action of the enzyme and the decomposition of the oil.

Cattle frequently show a marked distaste for rice bran as a food. It has been found, in such cases, that the bran has a rancid taste. The oil in rancid bran usually has a high acid number indicating that the fats (glycerides) have decomposed and, to a considerable extent, have been converted into free fatty acids. Data showing the hydrolysis of rice oil, when the bran is allowed to stand for seven days, are given in Table 22.

TABLE 22.—*Hydrolysis of the fatty oil when rice bran is stored.*

	Sample.				
	1	2	3	4	5
Acid number of oil:					
From fresh bran	2.4	4.1	4.4	5.1	13.6
From bran stored seven days	17.0	24.8	30.7	34.2	58.9

The greater the amount of free fatty acids contained in the oil of fresh bran the greater the amount of hydrolysis.

We determined the daily hydrolysis of the fatty oil when rice bran is stored for twenty-one days. In the first sample of bran tested the acid number of the oil in the fresh bran was 4.88 and in the second sample it was 8.89. These samples of bran were taken fresh from the polisher, placed in bags of cheesecloth, and stored in a wire screen box. They were thus exposed to atmospheric moisture but protected from insects. The results are recorded in Tables 23 and 24.

TABLE 23.—*Daily hydrolysis of the fatty oil when fresh rice bran is stored.*

[Acid number of oil in fresh bran, 4.88.]

Number of days stored.	Acid number of oil in bran.	Free fatty acids (in oil) calculated as oleic acid.	Daily increase in free fatty acids (as oleic).	Actual amount of fat (as olein) hydrolyzed each day.	Purity of fat (as olein) in bran.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
0	4.88	2.45			97.44
1	10.28	5.17	2.72	2.84	94.60
2	15.49	7.79	2.62	2.73	91.87
3	20.08	10.09	2.30	2.40	89.47
4	23.77	11.95	1.86	1.94	87.53
5 [a]			1.44	1.50	86.03
6	29.50	14.83	1.44	1.50	84.53
7	32.93	16.55	1.72	1.79	82.74
8	35.66	17.92	1.37	1.43	81.31
9 [a]			1.25	1.30	80.01
10	40.52	20.43	1.25	1.30	78.71
11	43.49	21.86	1.43	1.49	77.22
12 [a]			1.01	1.05	76.17
13	47.50	23.88	1.01	1.05	75.12
14	49.98	25.12	1.24	1.29	73.83
15	51.54	25.90	0.78	0.81	73.02
16	53.93	27.10	1.20	1.25	71.77
17	54.98	27.64	0.54	0.56	71.21
18	57.61	28.96	1.32	1.37	69.84
19 [a]			1.15	1.20	68.64
20	62.19	31.26	1.15	1.20	67.44
21	64.24	32.29	1.03	1.07	66.26

[a] Acid value was not determined on this day. The results were calculated from data obtained the following day.

As shown by the data, when both samples of bran were stored, there was a great increase in the acid number of the oil and, of course, a corresponding increase in the amount of free fatty acids calculated as oleic acid. Since the free fatty acids are formed by a splitting of the fat, naturally the purity of the fat gradually decreased. Rice oil, which originally contained 95.33 per cent of fats (Table 24), was found to have only 49.39 per cent of fats after the bran had been stored for twenty-one days. During these three weeks of storage nearly half of the fats in the fatty oil was decomposed (hydrolyzed) and converted into glycerol and a mixture of free fatty acids.

For both samples of bran (Tables 23 and 24) the amount of free fatty acids in the oil more than doubled during the first day the bran was stored. After that the daily increase in free fatty acids and the actual amount of fat hydrolyzed each day gradually decreased. That is, the rate of formation of free fatty acids in the oil decreased when the bran was stored. Lewkowitsch[66] states that, with castor oil, the more castor seed ferment present the greater the amount of hydrolysis. Increasing the amount of water also increases the hydrolysis. Free fatty acids, however, inhibit the action of the ferment. In our experiments we also found (Tables 23 and 24) that as the percentage of fatty acids increases the rate of hydrolysis decreases.

TABLE 24.—*Daily hydrolysis of the fatty oil when fresh rice bran is stored.*

[Acid number of oil in fresh bran, 8.89.]

Number of days stored.	Acid number of oil in bran.	Free fatty acids (in oil) calculated as oleic acid.	Daily increase in free fatty acids (as oleic).	Actual amount of fat (as olein) hydrolyzed each day.	Purity of fat (as olein) in bran.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
0	8.89	4.47	----------	----------	95.33
1	19.60	9.86	5.39	5.63	89.70
2	27.96	14.05	4.19	4.38	85.32
3[a]	----------	----------	3.12	3.16	82.16
4	40.39	20.30	3.12	3.16	78.79
5	47.02	23.63	3.33	3.48	75.31
6	52.23	26.25	2.62	2.73	72.58
7	57.83	29.07	2.82	2.95	69.63
8	61.29	30.80	1.73	1.81	67.82
9	63.76	32.05	1.25	1.30	66.52
10[a]	----------	----------	1.84	1.93	64.59
11	71.10	35.74	1.84	1.93	62.66
12	74.17	37.28	1.54	1.61	61.05
13	77.28	38.84	1.56	1.63	59.42
14	79.95	40.19	1.35	1.41	58.01
15	80.86	40.65	0.46	0.48	57.53
16	83.69	42.07	1.42	1.48	56.05
17[a]	----------	----------	1.61	1.68	54.37
18	90.12	45.30	1.61	1.68	52.67
19	93.00	46.74	1.44	1.50	51.17
20	95.09	47.80	1.06	1.10	50.06
21	96.38	48.44	0.64	0.66	49.39

[a] Acid value was not determined on this day. The results were calculated from data obtained the following day.

PRESERVATION OF RICE BRAN

Preliminary heating experiments.—According to Browne[67] the activity of the fat-splitting enzyme contained in rice bran can be retarded very considerably by heating the bran to a temperature of 90° C. To prevent the formation of free fatty acids in rice oil and the resulting rancidity Browne suggested heating the bran, immediately after milling, to a dry heat sufficient to destroy the enzyme, such as is done in the kiln-drying of certain seeds.

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[66] Chemical Technology and Analysis of Oils, Fats, and Waxes 1 (1921) 94.

[67] Journ. Am. Chem. Soc. 25 (1903) 948.

We carried out a number of preliminary experiments to get an idea as to the temperature and length of time necessary to heat the bran in order to stop the enzyme action and prevent hydrolysis of the fatty oil contained in the bran.

In heating the bran we used an ordinary electric drying oven which was fitted with an automatic stirrer. The bran was placed in a large crystallizing dish and stirred continuously during the heating in order to keep it at a uniform temperature. Then it was placed in cheesecloth sacks and stored in a wire screen box. Results of these experiments are given in Table 25.

TABLE 25.—*Acid number of fatty oil after heating and storing rice bran in cloth sacks.*

Sample.	Acid number of oil in fresh bran (not heated).	Time of heating bran.		Acid number after storing bran—	
		Temperature 90°–95° C.	Temperature 98°–100° C.	Seven days.	Fourteen days.
		Hrs.	*Hrs.*		
6	4.8			32.9	49.9
7	8.8			57.8	79.9
8	7.2	2		21.0	34.9
9	7.4	3		19.1	32.8
10	7.5	4		16.4	28.3
11 [a]	5.9		2	16.1	
12 [a]	5.9		3	15.8	
13 [a]	5.9		4	13.4	
13–A	7.3		5	15.5	
13–B	6.8		6	12.7	

[a] These three samples were taken from the same lot of bran.

As shown by the data (Table 25) the acid number of the fatty oil in samples of bran (Nos. 6 and 7), which were not heated, increased considerably when the bran was stored. These data are included in the table merely for comparison. When the bran was heated the acidity of the fatty oil was much less than when the bran was not heated. Heating the bran did not stop the acidity of the oil from increasing but merely retarded the formation of free fatty acids. Moisture is removed by heating the bran and quite likely some of the enzymes are also destroyed.

With less moisture and enzymes present the hydrolysis of the oil is inhibited.

Increasing the time of heating and the temperature retards the rise in the acid number of the oil. Heating the bran at a temperature of 98° to 100° C., for six hours gave the best results in these preliminary experiments.

Wrappers for heated bran.—Even if heating the bran under the proper conditions prevents the formation of free fatty acids in the fatty oil contained in the bran, it is necessary to keep the heated bran in some kind of a closed container, otherwise the bran soon becomes infested with insects. We carried out another set of experiments by heating the bran at a temperature of 100° C., for three to six hours. The bran, after heating, was placed in paper bags, which were then wrapped in various kinds of paper or wrappers as a protection against such agencies as moisture and insects. The samples were stored in a wire screen box. In these experiments we wished to find a satisfactory and cheap container or wrapper for the bran. The results are recorded in Table 26.

As shown by the data (Table 26) the acidity of the fatty oil increases slightly during the heating of the bran. That is, the acid number of the oil after heating is slightly higher than before heating. This is due to the fact that the fat-splitting enzymes become more active with rise in temperature until the heat causes inactivity and finally destroys the enzymes.

As in the first experiments, heating the bran for six hours at a temperature of about 100° C., gave the best results (samples 14, 15, 20, 21, 22). Heating the bran for shorter periods of time gave a larger increase in the acid number of the fatty oil when the bran was stored.

Of the various materials in which we wrapped the paper packages of rice bran, after heating, we found that moisture-proof cellophane seemed to give the best results. The acid number of the fatty oil in sample 15 (Table 26) did not increase after storing the bran one month. The acid number in sample 14 scarcely increased even after storing the bran for two months. Cakes made from this bran after two months of storage were just as good as those made from fresh bran. Probably if this sample had not been opened for analysis, and thus exposed to moisture, we could have kept it much longer without any appreciable increase in acidity. However, storing it for another month, after opening the package, raised the acidity of the fatty oil to an acid number of only 8.1.

TABLE 26.—*Acid number of fatty oil after heating and storing rice bran in paper bags wrapped in different kinds of paper.*

Sample.	Acid number of oil in fresh bran.	Time of heating at 100°C.	Acid number of oil in bran.			Kind of paper used for wrapping bran sample after heating.
			After heating and before storing.	Months stored.		
				1	2	
		Hrs.				
13-C	8.6	4	8.8	10.1	--------	Cellophane.
14	4.8	6	5.4	--------	5.5	Do.
15	6.6	6	7.9	7.9	--------	Do.
16	4.9	3	6.3	16.2	43.4	Heavy wax paper.
17	6.6	4	7.3	15.1	44.7	Do.
17-A	6.6	4	7.3	--------	37.0	Do.
18	8.9	5	11.5	16.9	43.3	Do.
18-A	8.9	5	11.5	--------	36.7	Do.
19	8.1	5	9.0	11.0	26.9	Do.
20	6.2	6	7.5	8.5	22.6	Do.
20-A	6.2	6	7.5	--------	19.9	Do.
21	7.4	6	9.2	10.3	20.9	Do.
21-A	7.4	6	9.2	--------	17.8	Do.
22	4.0	6	4.8	5.4	11.1	Do.
23	7.4	3	8.2	26.9	--------	Coarse wax paper.
24	6.4	4	7.0	24.6	--------	Do.
25	5.3	5	6.1	11.8	--------	Do.
26	6.9	5	8.1	20.0	--------	Do.
27	9.2	6	9.9	15.7	--------	Do.
28	8.5	6	9.2	13.4	--------	Do.
29	8.4	--------	8.4	96.3	--------	Green paper.
30	8.4	4	8.7	44.7	--------	Do.
33	6.6	--------	6.6	109.6	--------	Black paper.

If the bran can be kept a month with very little change in acidity of the fatty oil, quite likely it could be stored very much longer without any very appreciable deterioration.

We obtained fairly good results with a heavy wax paper. As shown by the data for samples 20, 21, and 22 there was only a very small increase in acidity when the heated bran was stored one month. Storing the bran for a second month gave a considerable increase in the acid number of the fatty oil. Evidently the wax paper is much inferior to cellophane for preserving the bran. However, after storing the heated bran for two months, those samples with a high acid number did not show any signs of rancidity.

When a coarse wax paper was used for storing the bran our results were not so good (samples 23 to 28). When the paper was folded the waxed surface cracked thus admitting atmospheric moisture.

We also used colored papers (green and black). The bran was placed in a paper bag which was then wrapped in several thicknesses of the colored paper.

Coe and Le Clerk [68] studied the keeping qualities of oil-bearing foods wrapped in colored papers. Concerning rice bran they state:

> Rice bran and polish were wrapped in various colored cellophane and exposed to direct sunlight. This experiment resulted in the discovery which is the subject of this paper, viz., that certain wave lengths of light promote rancidity, while certain others exert a protective action against this change. – – – – The use of a black wrapper or one of the proper shade of green will protect the food product for a sufficiently long time to permit of its sale and consumption before spoilage by rancidity develops.

Our results showed that these colored wrapping papers (samples 29, 30, and 33) are not very effective in retarding the hydrolysis of rice oil. When fresh bran (not heated) was stored one month in paper packages wrapped in these colored papers the acid number of the rice oil increased from about 8 to more than 90. These colored papers retarded the rancidity of the bran for, when tested by the kreis method, these samples showed only incipient rancidity. Heating the bran four hours retarded hydrolysis but the acid number after storing one month was considerably higher for the colored paper than for the heavy wax paper (sample 17).

The results of this second set of heating experiments indicate that a method, which may be used for preserving rice bran, is to take bran fresh from the mill polisher and heat it at a temperature of 100° C., for six hours. This treatment removes all the moisture and checks the action of enzymes. If the bran, after heating, is packed in moisture-proof containers it may be kept for several months in a fresh condition. As explained later, subsequent experiments showed that by heating the bran at a temperature somewhat above 100° C., the time required for heating the bran can be reduced considerably.

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[68] Cereal Chemistry 9 (1932) 519.

Since a double wrapping of moisture-proof cellophane preserved the bran better than any other wrapper we used it would seem that preservation of the bran, after heating, depends principally on excluding moisture and insects.

Enzymes in rice bran.—The fact that we had to heat rice bran at a temperature of 100° C., for six hours to check the action of the fat-splitting enzymes would seem to indicate that the enzymes in rice bran, like certain enzymes from other sources, have a considerable tolerance for heat.

Lewkowitsch[69] cites an observation made by Nicloux concerning castor seed "cytoplasma." This is the colloidal matter which occurs in the cells of the seed and naturally contains castor-seed enzymes. This castor seed "cytoplasma," which, under suitable conditions, causes rapid hydrolysis of oils and fats, if suspended in oil, may be heated for twenty hours at a temperature of 100° C., without losing its fat-hydrolyzing power.

According to Williams[70]—

> The temperature at which enzymes are rapidly destroyed varies with the particular enzyme and also with the conditions. For many enzymes 70°–80° brings about rapid destruction but some enzymes of bacterial origin are able to withstand 100° for a short time in an aqueous medium. If enzyme preparations are dried and heated in the dry condition they are able to withstand much higher temperatures. This is somewhat in line with the fact that we have already noted that enzymes are colloidal in nature and their destruction is due to the destruction of the colloidal condition. When dry, enzymes are not in the colloidal state and apparently are unaffected by conditions that will destroy them while in the colloidal condition.
>
> Enzyme preparations which have undergone much purification are more readily destroyed than cruder preparations. The impurities apparently afford protection of some sort; some impurities no doubt act as protective colloids. The presence of the substrate in some cases protects an enzyme against destruction by heat.
>
> Interesting cases of reactivation of enzymes which should throw light on their character have been reported. Amylase from Aspergillus oryzae [rice mold], which has been destroyed [rendered inactive] by heating to 95°, regains its activity by standing several days. Similar results have been obtained with a few other enzymes. This result lends support, perhaps, to the idea that enzymes are actually the colloidal substances themselves rather than active catalysts on colloidal "carriers."

From our experiments it would appear that heating rice bran, at a temperature of 100° C., for six hours, does not really destroy the enzymes but merely renders them dormant. As shown by the data (Table 27) when fresh rice bran was heated under the proper conditions and stored in a moisture-proof package there was no appreciable increase in the acidity of the fatty oil contained in the bran (samples 14 and 15). When the heated bran was allowed to absorb moisture the acidity of the fatty oil increased (samples 27 and 13–B). However, this increase in acidity was not nearly so great as when the bran was not heated (sample 6).

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[69] Chemical Technology and Analysis of Oils, Fats, and Waxes 1 (1921) 53.

[70] Introduction to Biochemistry (1931) 236.

TABLE 27.—*Effect of moisture on stored rice bran.*

Sample.	Time of heating at 100° C.	Time stored.		Acid number of oil in bran.		Wrapper used.
				Before storing.	After storing.	
	Hrs.	*Days.*	*mos.*			
14	6	0	2	5.4	5.5	Moisture-proof cellophane.
15	6	0	1	7.9	7.9	Do.
27	6	0	1	9.9	15.7	Coarse wax paper not quite moisture proof.
13–B	6	7	0	6.8	12.7	Cloth sack, not moisture proof.
6	----------	7	0	4.8	32.9	Sample (not heated) stored in cloth sack not moisture proof.

When rice bran is heated sufficiently moisture is removed and the enzymes in dry condition apparently lose their active colloidal character. Under favorable conditions, such as absorption of moisture, the enzymes gradually regain their colloidal character and again become active as indicated by the increase in the acidity of the fatty oil.

Testing fat-splitting enzyme activity.—We carried out some experiments to ascertain the keeping properties of rice bran heated above 100° C. We heated the bran, with constant stirring, at 120° C., for six hours. To test the enzyme activity and resulting hydrolysis of the rice oil in the bran, the hot bran was quickly placed in a sterilized glass bottle and sterilized cotton was inserted in the top of the bottle. Paper laid over the cotton served to keep out dust. Under these conditions the bran could absorb moisture through the cotton stopper.

If the enzymes are destroyed by heating the bran at the higher temperature then the acidity of the fatty oil should not increase when the bran absorbs moisture under these conditions; for, in the absence of enzymes or other catalysts, moisture is not effective in hydrolyzing vegetable oils at ordinary temperatures.

For comparison we stored in sterilized bottles and under the same conditions two other samples of bran. One was a sample of fresh bran which was not heated and the other was a sample heated at 100° C., for six hours. The results of storing these three samples for thirty-one days are recorded in Table 28.

TABLE 28.—*Testing the activity of fat-splitting enzymes in rice bran.*

[The bran was stored for thirty-one days in sterilized bottles with sterilized cotton as stoppers.]

Sample.	Time of heating.		Moisture.		Acid number of oil in bran.	
	100° C.	120° C.	Before storing.	After storing.	Before storing.	After storing.
	Hrs.	*Hrs.*	*Per cent.*	*Per cent.*		
34 [a]	--------	--------	14.3	19.6	4.4	143.8
35 [b]	6	--------	----------	5.4	5.8	22.1
36 [b]	--------	6	----------	5.2	6.8	8.0

[a] The fresh bran, which was not heated, became moldy during storage.

[b] Sample was moisture free before storing.

The bran (sample 34) that was not heated had a high moisture content and on this account became moldy during storage and the fatty oil in it hydrolyzed to an unusual extent as indicated by the high acid number (143.8).

Both samples of the heated bran had a pleasant, sweet odor and were in very fresh condition after they were stored for thirty-one days.

The bran which was heated at a temperature of 100° C., (sample 35) absorbed 5.4 per cent moisture. Heating the bran at this temperature did not destroy the enzymes but merely rendered them inactive, for with absorption of moisture the enzymes again became active and the acid number of the fatty oil in the bran increased from 5.8 to 22.1.

Bran heated at a temperature of 120° C., (sample 36) absorbed 5.2 per cent moisture, but the acidity of the fatty oil increased only very slightly. From these results it would seem that by heating the bran at the higher temperature nearly all the enzymes are destroyed, as the fatty oil is only very slightly hydrolyzed when the bran absorbs moisture during storage. Quite likely the very few enzymes that remain are not active enough to cause any serious deterioration when the bran is stored for a much longer period of time.

Rice bran heated at about 100° C., for six hours and stored in a moisture-proof container apparently has excellent keeping properties (Table 27). However when the bran is stored, in a sterilized bottle where moisture can enter, there is quite an increase in the acidity of the fatty oil in the bran (Table 28). It would seem that bran thus heated, really does not have such good keeping properties and only keeps well under special conditions. Storing the bran properly with access to moisture and subsequently determining the acidity of the rice oil, seems to be a good method for testing the keeping properties of the bran. It affords a reliable means of ascertaining the results of enzyme activity under favorable conditions.

Temperature and time of heating rice bran.—In preparing rice bran which will keep in storage commercially the shorter the time necessary to heat it the better, for it makes the process less expensive and more convenient to carry out. The results of our experiments on heating the bran and storing it in sterilized bottles indicate that the most appropriate temperature for heating is between 100° and 120° C., and the time is six hours or less. In order to ascertain more exactly the best heating conditions we carried out another set of experiments by heating the bran at various temperatures between these limits and for different intervals of time. As in the previous experiments the bran was again stored, with access to moisture, in sterilized bottles. The results are recorded in Table 29.

TABLE 29.—*Temperature and time of heating rice bran to prevent deterioration in storage.*

[The bran, after heating, was stored for thirty-one days in sterilized bottles with sterilized cotton as stoppers.]

Sample.	Time of heating.			Moisture after storing.	Acid number of oil in bran.	
	105° C.	110° C.	115° C.		Before storing.	After storing.
	Hrs.	*Hrs.*	*Hrs.*	*Per cent.*		
37	3			5.77	4.56	18.88
38	4			5.76	5.12	16.86
39		3		6.22	5.28	17.52
40		4		6.12	5.63	15.49
41			3	6.87	4.67	16.65
42			4	5.60	5.59	12.06

NOTE.—The samples of bran were moisture free before storing.

As shown by the data (Table 29) when rice bran is heated below 120° C., and stored there is a decided increase in the acidity of the fatty oil contained in the bran. This shows that the enzymes are not all destroyed at temperatures between 100° C., and 120° C. Since rice bran heated above 105° C., acquires a rather dark color, which is not desirable, it would seem that heating the bran at 105° C., for three hours affords heating conditions about as appropriate as any. Heating the bran under these conditions and storing it in moisture-proof containers would serve to keep the bran in good condition for a considerable length of time.

Heating the bran removes moisture and stops the destructive action of enzymes, as most of them are destroyed. This prevents decomposition and subsequent rancidity of the fatty oil contained in the bran. The heating does not affect the vitamins but destroys any mold spores, insects, or insect eggs which may be in the bran. When stored in moisture-proof containers, the heated bran does not become rancid, moldy, or infested with insects.

Bacteria in rice bran.—If the fatty oil in rice bran has the general properties of other vegetable fatty oils then the decomposition (hydrolysis) of rice oil in rice bran is due to moisture in the presence of fat-splitting enzymes contained in the tissues of the bran. The question might be raised that, possibly, bacteria as well as enzymes may, perhaps, be active in decomposing the fatty oil in rice bran. In order to settle this question we heated rice bran at a temperature of 120° C., for six hours. During the heating the bran was stirred continually. The heating destroyed the bacteria and also any mold spores or insect eggs that may have been in the bran. A portion of the hot bran was quickly placed in a sterilized bottle which was stoppered with sterilized cotton. Another portion of the heated bran was placed in an open vessel and thus exposed to bacteria in the air. This bran was stirred occasionally and allowed to stand in the air for four hours. It was then placed in a sterilized bottle which was stoppered with sterilized cotton. These two samples were covered with paper to keep out dust and allowed to stand in the air, under identical conditions, and absorb moisture through the cotton stoppers for 31 days.

The first sample quite likely contained only a very few bacteria while the second, which was allowed to stand in the air, certainly had considerably more than the first. For comparison we simply designated the first sample as "without bacteria" and the second as "with bacteria." The results of these experiments are recorded in Table 30.

TABLE 30.—*Effect of bacteria on the decomposition of rice oil in rice bran.*

[The bran was heated at 120° C., for six hours and stored for thirty-one days, exposed to moisture, in sterilized bottles.]

Rice bran.	Moisture.		Acid number of oil in bran.	
	Before stirring.	After storing.	Before storing.	After storing.
Without bacteria [a]	----------	4.50	4.60	6.18
With bacteria [b]	----------	4.73	[c] 4.60	6.45

[a] The bran, heated for six hours at 120° C., was placed immediately in a sterilized bottle which was stoppered with sterilized cotton.

[b] The bran, heated as above, was placed in an open vessel and exposed to the air, with occasional stirring, for four hours. The bran was then placed in a sterilized bottle which was stoppered with sterilized cotton.

[c] The acid number was determined after heating the bran and not after exposing it to the air for four hours.

If bacteria are active in hydrolyzing rice oil then, after storage, the rice oil in the bran with bacteria should have a much higher acid number than the rice oil in the bran without bacteria. As shown by the data (Table 30) both samples gave about the same results so evidently the decomposition of rice oil in rice bran is not due to bacteria.

The acid number of the rice oil in both samples of bran increased slightly during storage. This would seem to indicate that the enzymes in rice bran are not totally destroyed even after the bran is heated at a temperature of 120° C., for six hours. Apparently a very few still remain somewhat active.

The rice oil in the bran with bacteria gave a slightly greater increase in acidity, during storage, than the oil in the bran without bacteria. This was probably due to the fact that the bran with bacteria was stirred in the air for four hours before bottling and absorbed more moisture than the bran without bacteria. Both samples of bran were moisture free immediately after heating.

Sieving rice bran before heating.—Commercial rice bran usually contains some fragments of rice kernels or polished rice. It may also have some broken rice hulls or other foreign matter if the bran has not been milled properly. If the bran is to be used for making bakery products or other foods, it should be sieved as it is not desirable to have hard particles in the bran and moreover rice hulls are considered to be injurious for human consumption. In sieving the bran the hard particles are retained by the sieve. The question naturally arises as to how much of the nutritious constituents are removed from the bran by sieving it. We obtained two samples of fresh rice bran (200 grams each) and, by analysis, found the oil content of one to be 21.88 per cent (calculated on a moisture-free basis) and the other to be 23.51 per cent. This showed that these samples of bran were not purposely adulterated with rice hulls. These samples were sieved through a large, 30-mesh, inclined sieve. Dr. A. J. Hermano tested the fine bran which passed through the sieve and also the coarse material retained by the sieve for the fat-soluble vitamin A and the water-soluble vitamin B_1. Both the fine bran and the coarse material gave positive tests for these vitamins (Table 31).

The coarse material consists largely of fragments broken off from the surface of the rice kernel. These fragments contain a considerable portion of the aleurone layer of the rice kernel and therefore they contain rice oil, fat-soluble vitamins and also the water-soluble vitamin B_1.

TABLE 31.—*Rice oil and vitamins (A and B_1) in sieved bran.*

Sample.	Bran retained by 30-mesh sieve.			Bran passing through 30-mesh sieve.		
	Amount.	Vitamins (A and B_1).	Oil content of bran.	Amount.	Vitamins (A and B_1).	Oil content of bran.
	Per cent.		*Per cent.*	*Per cent.*		*Per cent.*
1	13.00	Positive	24.81	87.00	Positive	21.59
2	15.50	do	24.25	8 .50	do	23.19
Average	14.25		24.53	85.75		22.39

As shown by the data an average of 14.25 per cent of coarse material was removed from the bran by sieving it. This is about 1 per cent less than the average of the results recorded in Table 3. Since this coarse material contained 24.53 per cent fatty oil then the amount of fatty oil removed from the bran by sieving was about 3.5 per cent ($14.25 \times 0.2453 = 3.49$). The coarse material removed by sieving is very suitable for feeding chickens or for other purposes.

In sieving rice bran through a large, 30-mesh, inclined screen the bran does not sieve by mechanically shaking the screen because there are no oval solid particles, like rice grains, to roll down the screen. However, if the bran is spread over the screen in a thin layer and the screen is tapped frequently with a rod, so that the screen vibrates perpendicularly, then the fine bran will pass quickly through the screen while the coarse material is retained. The coarse material is then removed and a new portion of bran spread over the screen.

Rice-bran cooker.—The Bureau of Science has recently installed a rice-bran cooker (Plate 10). This cooker is a drum-shaped apparatus which has an internal diameter of 100 centimeters and an internal height of 40 centimeters. The side and bottom are surrounded by a jacket through which steam may be admitted when the cooker is in operation. In the interior of the cooker and very near the bottom there is a stirrer with four iron paddles that serve to stir the bran when it is heated. Layers of asbestos wrapped around the outside of the cooker prevent loss of heat. This cooker heats the bran satisfactorily, in fact, the bran may be heated easily to a temperature of 125° C.

Our method for preparing rice bran so that it will keep in storage is as follows: Bran fresh from the polisher is sieved through a large, 30-mesh screen by tapping the screen so that it will vibrate perpendicularly. The coarse material, which does not pass through the screen, may be discarded and used for feeding chickens. If it does not contain rice hulls or other foreign matter it may be ground finely and returned to the bran. The sieved bran is then placed in the cooker and heated, with continual stirring, for three hours at a temperature of about 105° C. Stirring the bran facilitates the removal of moisture. The bran while still hot is then packed in moisture-proof containers or packages. When prepared in this manner it will keep in a fresh condition for a considerable length of time.

Although the heated bran is slightly darker in color than the fresh, raw bran it has a pleasanter and sweeter odor and flavor than the raw bran.

Heating bran in outlying districts.—In outlying districts it is often not feasible to procure bran which has been properly heated in a cooker and stored in moisture-proof containers. Bran which will keep in storage for a short time may be prepared in a rather crude manner at home. This is done by simply heating fresh bran in a frying pan over a low fire. The bran should be stirred continually and heated about an hour or so until it turns slightly darker than the fresh bran. Care should be taken not to burn the bran. After it is heated the bran should be placed in a can or glass jar and this closed tightly to prevent entrance of moisture. This crude method removes nearly all of the moisture from the bran and by storing it in containers which are fairly air-tight the bran will keep in good condition for a week or more.

Rice bran is at present a very cheap substance and contains fats, proteins, and vitamins that are the most nutritious constituents of the rice grain. Excellent bakery products and other foods may be made from rice bran. When it is not convenient to procure fresh bran the heated bran, preserved in proper containers, may be used. It is preferable to use the heated bran because it keeps better than raw bran.

SUMMARY

Rice cultivation.—There are many varieties of rice grown in the Philippines. These different varieties are distinguished by their physical characteristics and recorded under permanent numbers in the Philippine Bureau of Plant Industry. During the years 1921 to 1930 the average yearly production of paddy rice was more than two million metric tons.

Rice straw.—Rice straw, obtained as a by-product in threshing rice, is used for various purposes. It is especially suitable for cultivating mushrooms and for making tissue paper.

Philippine process of milling rice.—In the Philippine process of milling the paddy rice is passed through a rice huller which breaks the hulls. The mixture of broken hulls, unpolished (hulled) rice, and paddy rice (not broken) is sieved to remove fine particles and then carried to the blower. This removes the hulls which are usually taken to the boiler to be used as fuel. The mixture of unpolished rice and paddy rice is next taken to the separator, which removes the paddy rice from the unpolished rice. The paddy rice is returned to the rice huller while the unpolished rice goes through the polisher. In the polishing process rice bran is removed from the rice kernel (unpolished rice) to produce white polished rice. The bran consists of the outer layer of the rice kernel together with the rice grain embryo.

Philippine rice-mill products consist principally of polished rice, hulls, bran, and small broken grain; also unpolished rice, when desired.

Samples of rice-mill products were collected from 14 Philippine mills. The data on these products, arranged in tabular form, afford a convenient means for checking up the efficiency of the principal rice-mill machinery—the rice huller, blower, separator, and polisher.

The Philippine process of milling rice is quite different from that used in the United States. In the Philippines the scraping and polishing of the grain are done in one machine—the rice polisher. In the United States these two operations are performed in separate machines. In Philippine mills the grain is broken in both the rice huller and polisher.

We compared the amount of whole and broken polished rice grains obtained during the milling of rice in Philippine and American mills. The results showed that the percentage of whole grains produced in Philippine mills, which have only one polisher, compares very favorably with the best results obtained in American mills.

Rice starch.—Although rice starch is not strictly a rice-mill product it has been mentioned, since it is an important commercial product made from polished rice. Compared to other starchy materials rice contains a relatively high percentage of starch. Rice starch is used commercially for various purposes such as laundering, preparing foods, making paste and medicinal tablets. It is also employed extensively in the cosmetic industry for making face powders, because the particles of starch are much finer than those of any other cereal and adhere excellently to the skin.

Rice hulls.—Rice hulls are used for various purposes such as fuel, packing hygroscopic materials, filtering, and percolating. They are also employed in making an edible rice cellulose. They consist largely of crude fiber and also have a rather high ash content. On account of their very high silica content the ashes of rice hulls, when finely powdered, serve as a good polishing powder. They may also be useful for making polishing pastes and scouring soaps.

Polished and unpolished rice.—After the paddy (unhulled) rice is passed through the rice huller to remove the hulls the unpolished (hulled) rice then goes through the polisher. There are several reasons for polishing rice. Polished rice is clean, white, and tasty in appearance whereas the unpolished rice is slightly colored and not so inviting. Polished rice has much better keeping qualities than unpolished rice. The unpolished rice loses its flavor in a tropical climate because the fats in it become rancid. Again the unpolished rice has a tendency to get moldy and become infested with weevils and other insects which destroy the outer mealy layer of the grain. Polished rice differs from unpolished rice in that the unpolished rice contains the nutritious constituents (fats, proteins, and vitamins) of the rice grain. Polished rice contains proteins but very little of the fats and vitamins.

Beriberi is a disease contracted by people who live on a diet composed principally of polished rice. When unpolished rice is used as a diet this disease is not contracted because the unpolished rice contains vitamin B_1 which prevents beriberi.

Nutritious parts of the rice grain.—Fats, proteins, and vitamins, the most nutritious constituents of the rice grain, are contained chiefly in the embryo and aleurone layer of the unpolished rice. The aleurone layer is the part of the rice kernel that lies just beneath the seed coat.

During the polishing process the entire seed coat of the unpolished rice is removed. The embryo (germ) is also removed as well as most of the aleurone layer of cells. Polished rice usually contains small portions (remnants) of the oily aleurone layer. The fatty oil contained in these portions of the aleurone layer becomes rancid when the polished rice is stored for some time and as a consequence the polished rice tends to lose its fresh flavor.

Rice bran.—That portion of the rice kernel removed during the polishing process is called rice bran. The rice bran is also known locally as darak, tikitiki or rice polishings. The bran contains the seed coat and germ of the unpolished rice (rice kernel). The bran also contains a considerable portion of the aleurone layer of the unpolished rice as well as some starchy material beneath the aleurone layer.

Most of the nutritious constituents of the rice grain (fats, proteins, and vitamins) are contained in the rice bran. High-grade bran, which is moisture free, should contain at least 20 per cent of vegetable fatty oil.

Rice bran suitable for human consumption should contain practically no rice hulls as it is generally believed that the hulls have an irritating effect upon the stomach and intestines. The presence of hulls in the bran may be determined by observing the bran under the microscope. In milling rice bran intended for edible purposes the mill should have a very efficient blower which will remove practically all the rice hulls from the unpolished rice. If the grain before polishing contains no hulls then the bran removed from the grain during the polishing process will also be free of hulls unless it is purposely mixed with them.

Rice-bran oil (*rice oil*).—Rice bran, which is moisture free, contains at least 20 per cent of fatty oil (rice oil). The oil consists principally of the glycerides of oleic, linolic, and palmitic acids. It is difficult to obtain the fatty oil from rice bran by pressure unless a high pressure (about 8,000 pounds) is used. However, the oil may be extracted by solvents such as ether and hot coconut oil.

Vitamins in rice bran.—Rice bran contains the water-soluble vitamin B_1 which prevents beriberi. The rice oil (fats) in rice bran contains the fat-soluble vitamins A and E. Vitamin A prevents eye afflictions and E sterility. Vitamin D, which prevents rickets, is developed in irradiated rice oil.

Tikitiki extract, made in the Bureau of Science, is an extract of rice bran containing vitamin B_1. It is used as medicine for curing beriberi.

The yield of tikitiki extract from rice bran varies considerably depending upon the quality of bran used in making the extract. During the year 1932 the average monthly production in the Bureau of Science was 69 bottles (50 cubic centimeters each) of extract for 1 sack (50 kilos) of bran. The potency of 1 cubic centimeter of this standard extract is about equivalent to that of 14.5 grams of high-grade rice bran.

Tests made for standardizing this extract showed that when 0.2 cubic centimeter of the extract is added daily to a basal ration deficient in vitamin B_1 the ration then contains sufficient vitamin B_1 to support a growing rat. Pigeons which had contracted polyneuritis were cured in one day when given an aqueous solution containing 0.0175 gram of the extract. The same results were obtained with 10 milligrams of activated clay which is equivalent to one unit of vitamin B_1. This activated clay serves as an international standard for vitamin B_1.

In the United States the use of vegetable oils, particularly coconut oil, in making margarine has increased very considerably in recent years. Coconut oil does not contain fat-soluble vitamins. Since rice oil contains the fat-soluble vitamins A and E it might serve as an important product for use in the margarine industry as the rice oil would supply the vitamins which are not contained in the coconut oil. Mixtures of coconut and rice oils should make a margarine more like natural butter than when coconut oil alone is used.

Rice oil is very much darker in color than coconut oil. Color tests on mixtures of rice and coconut oils show that, as the percentage of rice oil in the mixture increases, there is a much greater increase in the yellow hue than in the red.

Proteins and mineral constituents.—The proteins in rice bran appear to be comparable to soy-bean protein, which is similar to both meat and milk proteins. In their general amino-acid make-up the rice-bran proteins have a high biological value comparing favorably with meat proteins. The protein nitrogen content of rice bran is about 8 times the nonprotein nitrogen.

Rice bran contains a relatively large amount of phosphorus as compared to lime. These mineral constituents are unbalanced and so in this respect the nutritive value is deficient. For people who live on a diet containing rice bran, these mineral constituents may be balanced to a considerable extent by eating vegetables that have a high lime content.

Nutritive value of rice bran.—Rice bran is the most nutritious part of the rice, since it contains fats, proteins, and vitamins. It has excellent food constituents with a high calorific value and is more nutritious than hydraulic copra cake, wheat bran, Graham and straight grade flour. Rice bran not only serves as an excellent material for cattle food but it is also very suitable for human consumption. For people who do not care for the natural flavor of rice bran this may be toned down considerably by diluting the bran with wheat flour. A mixture consisting of 3 parts of wheat flour and 1 part of rice bran makes a good combination for bakery products such as bread and cakes. Rice bran does not contain gluten and so, when used alone, it does not make bread that will rise. The addition of wheat flour not only weakens the flavor of the bran but also supplies the gluten necessary for making bread. The bran flavor may be entirely neutralized or disguised by making the bakery products with other characteristic flavors, such as ginger, cinnamon, or chocolate.

In the Philippines beriberi is a very common and fatal disease among the poorer classes who live on a diet that consists principally of polished rice and is deficient in vitamin B_1. It has been estimated that for people who are susceptible to beriberi a small amount of rice bran (30 grams) contains about enough of the antineuritic vitamin B_1 for their daily requirements. This is about equivalent to 11 level (not heaping) teaspoonfuls of bran or approximately 2 cubic centimeters of standard rice-bran (tikitiki) extract. The annual production of rice bran in the Philippines is about sufficient for all the people who need the bran for its medicinal value and also for others who might benefit by using it.

Deterioration of rice bran.—Deterioration of rice bran is caused by insect infestation and also by the decomposition of rice oil. Rice bran contains a fatty oil (rice oil) in contact with fermentable vegetable tissue. When the fresh bran is stored the fats in the oil are decomposed (hydrolyzed) and converted into a mixture of free fatty acids and glycerol. This decomposition of the fats in rice oil is due to the action of moisture in the presence of vegetable tissue which contains fat-splitting enzymes. When this decomposition has proceeded to any considerable extent the rice oil usually becomes rancid and the bran acquires a disagreeable taste. A sample of fresh rice bran which originally contained 95.33 per cent of fats in the fatty oil, was found to have only 49.39 per cent of fats in the oil after storing the bran, with access to moisture, for twenty-one days. The greater the amount of free fatty acids contained in the fatty oil of fresh bran the greater the amount of hydrolysis when the bran is stored. However, the rate of formation of free fatty acids in the oil decreases on storing the bran.

Preservation of rice bran.—Our results indicate that the most convenient method for preserving rice bran is to heat the bran at a temperature of about 105° C., for three hours and then keep it in moisture-proof packages. Heating the bran removes moisture, stops the destructive action of the enzymes, destroys any mold spores, insects, or insect eggs which may be contained in the bran but does not affect the vitamins. The preservation of the bran, after heating, seems to depend principally on excluding moisture and insects. This may be accomplished satisfactorily by packing the bran in moisture-proof containers or wrappers. Bran, thus prepared, keeps well and does not become moldy, rancid, or infested with insects.

Of the various materials which we used to wrap the paper packages of rice bran, after heating, we found that moisture proof cellophane gave the best results. Tightly closed cans would very likely serve excellently for keeping the bran but such containers would be too expensive for the poorer classes.

The enzymes in rice bran have a considerable tolerance for heat. Heating the bran at a temperature of 100° C., for six hours, does not seem to destroy the enzymes but merely renders them dormant. When the bran is heated sufficiently moisture is removed and the enzymes in dry condition apparently lose their active colloidal character. Under favorable conditions, such as absorption of moisture, the enzymes gradually regain their colloidal character and again become active as indicated by increased acidity of the fatty oil in the bran.

Fresh bran heated at a temperature of 120° C., for six hours and stored, with access to moisture, for thirty-one days absorbed 5.2 per cent of moisture but the acidity of the fatty oil in the bran increased only very slightly. This would seem to indicate that nearly all the enzymes are destroyed at the higher temperature.

The activity of fat-splitting enzymes in rice bran, which has been heated, may be tested by storing the bran with access to moisture in a sterilized bottle and subsequently determining the acidity of the rice oil in the bran. This method affords a reliable means of ascertaining the results of enzyme activity under favorable conditions.

Tests carried out to ascertain if bacteria as well as enzymes are active in decomposing the fatty oil in rice bran showed that the decomposition of rice oil is not due to bacteria.

Commercial rice bran may contain some fragments of rice kernels and rice hulls. If the bran is to be used for making bakery products or other foods it is advisable to sieve it to remove the hard particles. In sieving the bran through a 30-mesh screen about 3.5 per cent of fatty oil is removed with the coarse material.

In preparing rice bran for storage it is advisable to use a specially constructed cooker containing a stirrer. Stirring the bran while heating facilitates the removal of moisture. The bran while still hot should be packed in moisture-proof containers.

In outlying districts where proper cooking facilities are not available the bran may be heated, with continual stirring, in a frying pan over a low fire. The heating should be continued until the bran turns slightly darker in color. After it is heated, the bran should be placed in a can or glass jar which may be closed tightly to prevent the entrance of moisture. The bran will thus keep in good condition for a week or more.

Although the heated bran is slightly darker in color than the fresh, raw bran it has a pleasanter and sweeter odor and flavor.

Résumé.—As a rice-mill by-product more than 111,000 tons of fine rice bran are produced annually in the Philippines. At present this material is very cheap and is used for feeding cattle and poultry. Rice bran contains fats, proteins, and vitamins, which are the most nutritious constituents of the rice grain. It would seem that rice bran has the characteristics of a very good food.

The reason that rice bran has not become a popular human food is probably due to the fact that it contains a quantity of vegetable fatty oil. When the bran is stored the oil becomes rancid and the bran acquires a disagreeable taste. In order to make the bran suitable for human consumption it is only necessary to separate the coarse material and to heat the fresh bran properly in order to remove all the moisture and stop the destructive action of the fat-splitting enzymes. The hot bran should then be stored in moisture-proof packages.

Excellent bakery products and other foods may be made from bran which has been properly heated and packed. On account of its nutritious constituents rice bran should serve as an important material for Philippine foods. For the poorer classes who live on a diet composed principally of polished rice and is more or less deficient in fats, proteins, and vitamins, the use of rice bran as a food would serve to supply, to a considerable extent, the present dietary deficiency. It would not only prevent sickness and death from beriberi but the health of the people would be generally improved. Moreover by utilizing this domestic by-product of the rice mills the Filipinos would be developing the natural resources of their own country, and the importation of rice and other foodstuffs from foreign countries would be greatly diminished.

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ILLUSTRATIONS

PLATE 1

FIG. 1. Rice field, Philippine Islands.
2. Rice panicles.
3. A single rice panicle.

PLATE 2

FIG. 1. Rice stacks ready for threshing.
2. Philippine rice mill.

PLATE 3. PHILIPPINE RICE MILL, INTERIOR VIEW

FIG. 1. Rice huller.
2. Blower.
3. Separator.
4. Polisher.

PLATE 4

FIG. 1. Rice huller opened and showing the grinding stones.
2. Rice huller, closed.

PLATE 5. RICE POLISHER

FIG. 1. Polishing stone.
2. Wire screen (part removed to show abrasive stone).
3. Outside view of rubber strip (polisher), showing adjustment screws.

PLATE 6. RICE GRAINS

FIGS. 1 and 4. Paddy (unhulled) rice.
2 and 5. Unpolished rice.
3 and 6. Polished rice.

PLATE 7

FIG. 1. Longitudinal section of paddy rice grain (Malagkit variety).
h, hull.
sc, seed coat.
al, aleurone layer of cells.
en, endosperm with starch cells.
c, cotyl.
p, plumule.
r, radicle.
em, whole embryo (comprising cotyl, plumule, and radicle).
2. Segment of a part (cotyledon) of the rice grain embryo.
sc, seed coat.
o, oil droplets.
p, protein granules.

FIG. 3. Segment of a cross section of unpolished grain (Macan variety).
  sc, seed coat.
  al, aleurone layer of cells.
  o, oil droplets.
  p, protein granules.
  sg, starch grains.

PLATE 8

FIG. 1. Cross section of unpolished rice grain (Macan variety).
  sc, seed coat.
  al, aleurone layer of cells.
  en, endosperm with starch cells.
2. Cross section of polished rice grain (Macan variety).
  al, part of aleurone layer of cells remaining after polishing.
  en, endosperm with starch cells.
3. Fragment of rice hull showing surface hairs.

PLATE 9

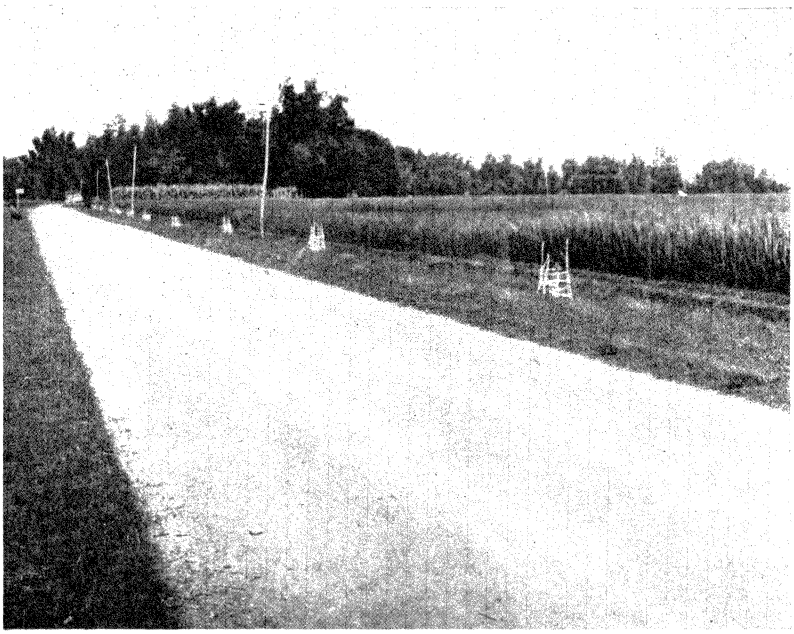
FIG. 1. Pigeon ill with polyneuritis.
2. Same pigeon cured after taking rice bran.
3. Albino rat ill due to vitamin A deficiency.
4. Same albino rat cured completely after taking rice-bran oil for two weeks.

PLATE 10

Rice-bran cooker for heating rice bran to prevent deterioration.

TEXT FIGURE

FIG. 1. Outline showing Philippine process of milling rice.



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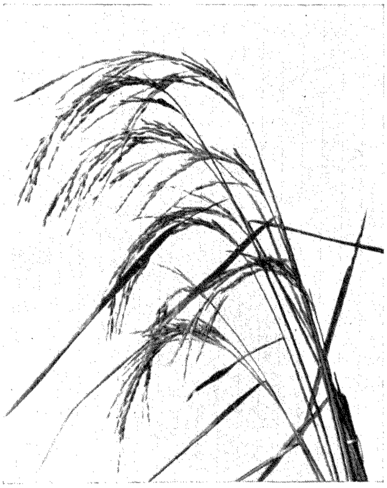

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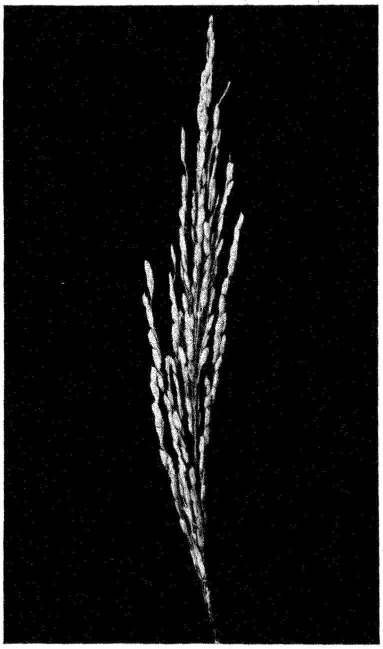

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PLATE 1.

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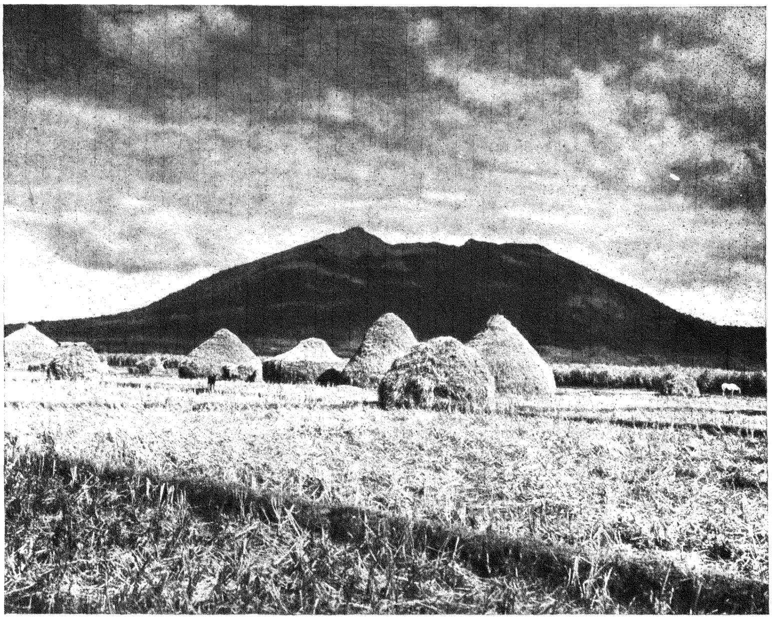

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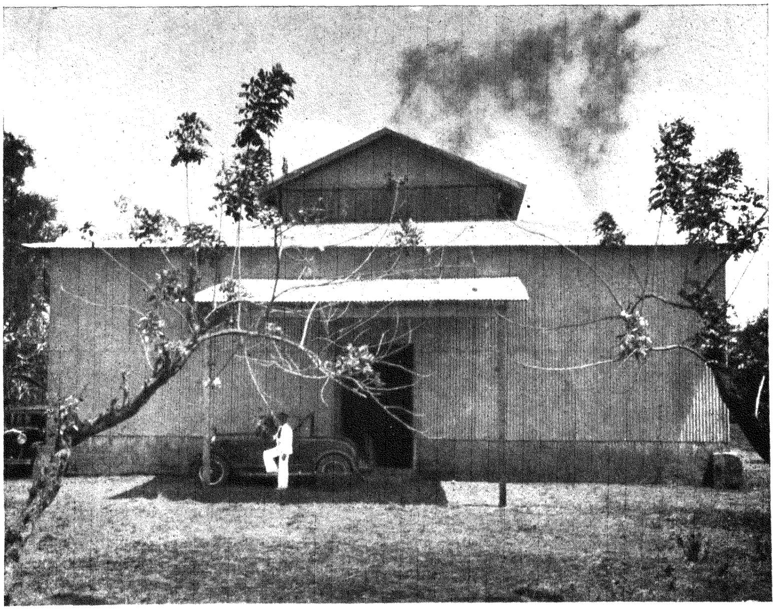

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PLATE 2.

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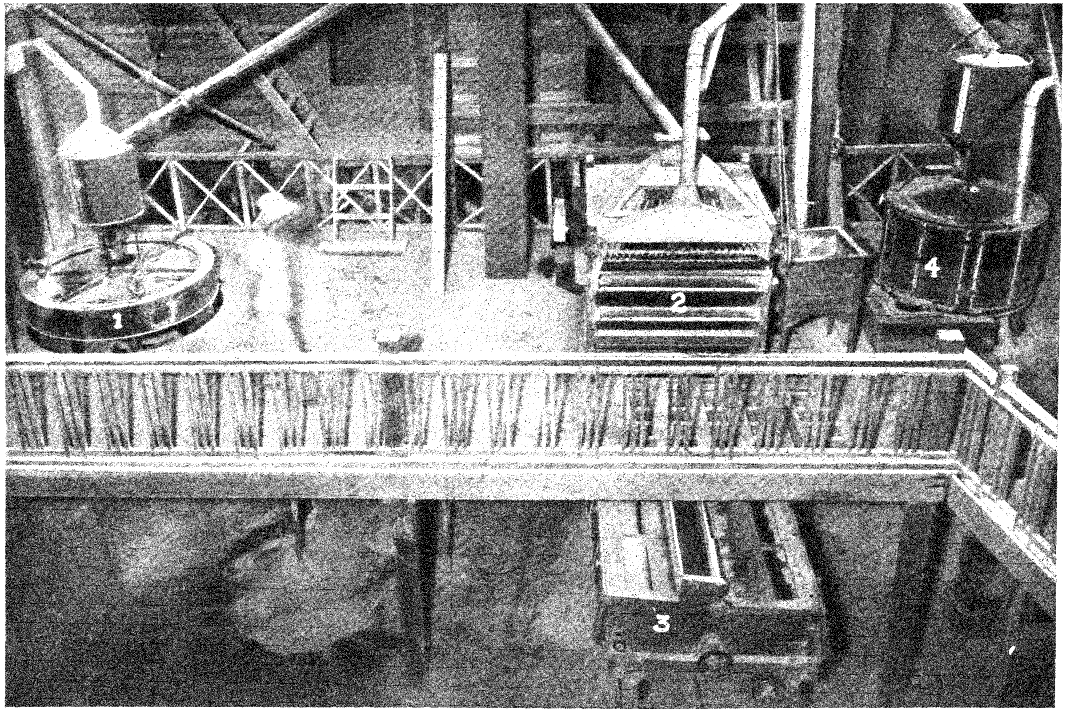

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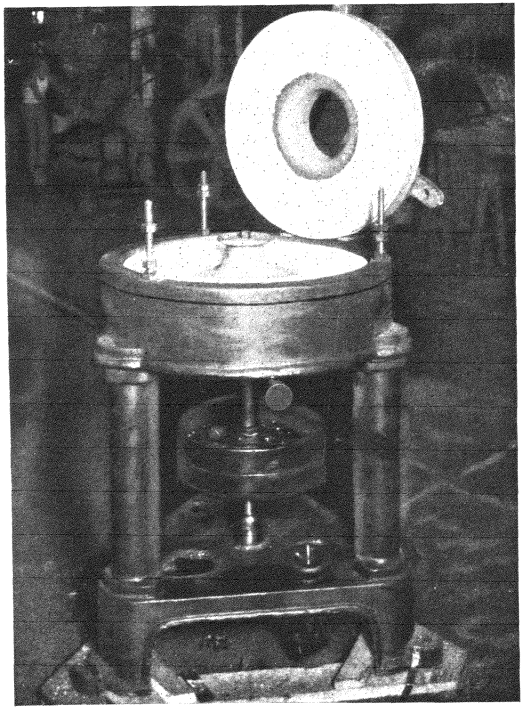

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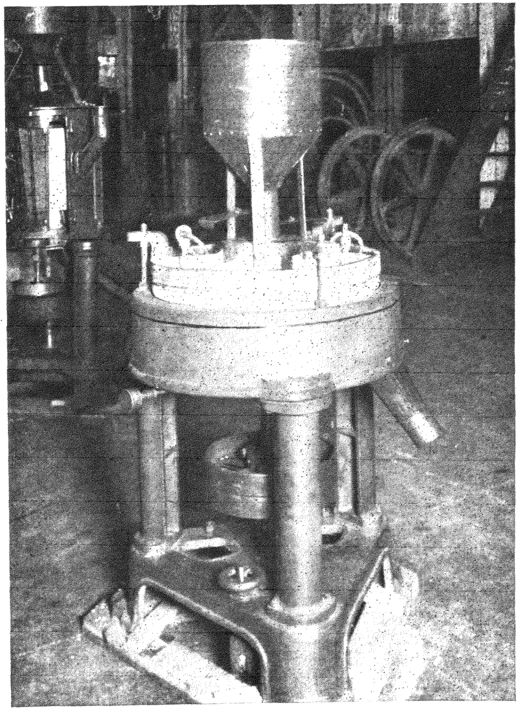

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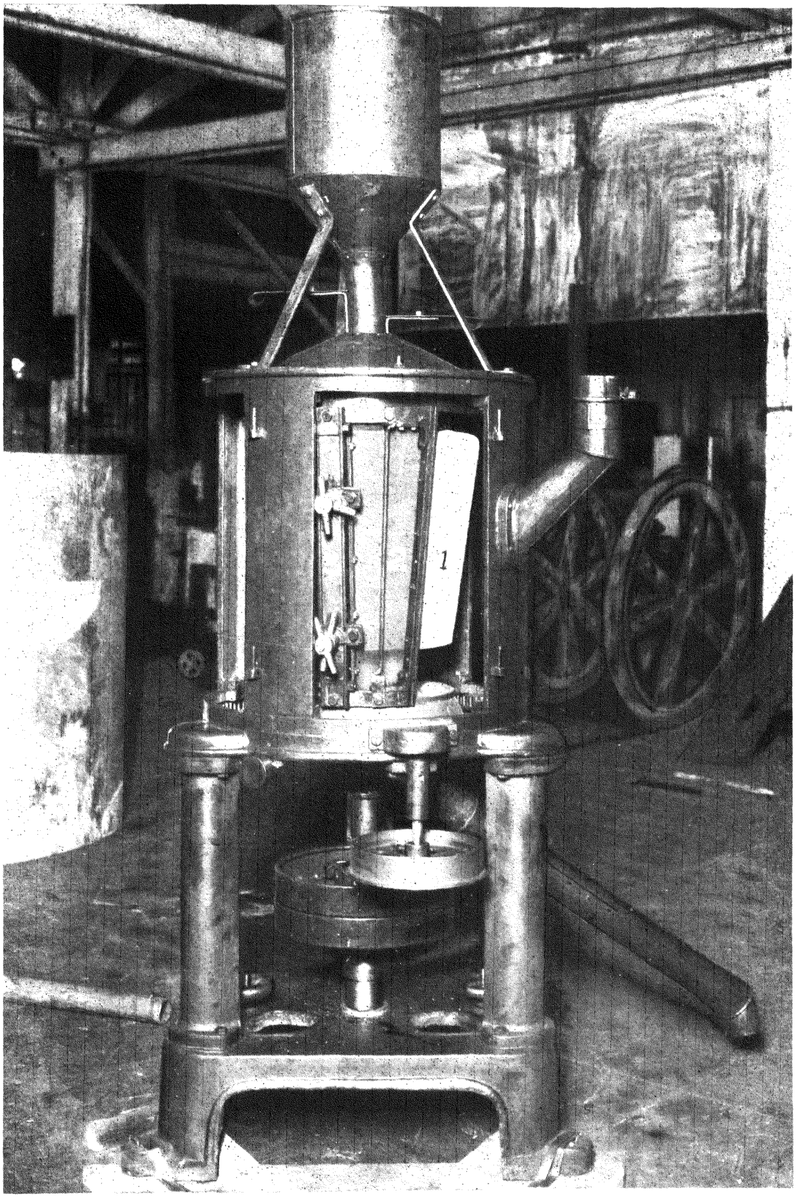

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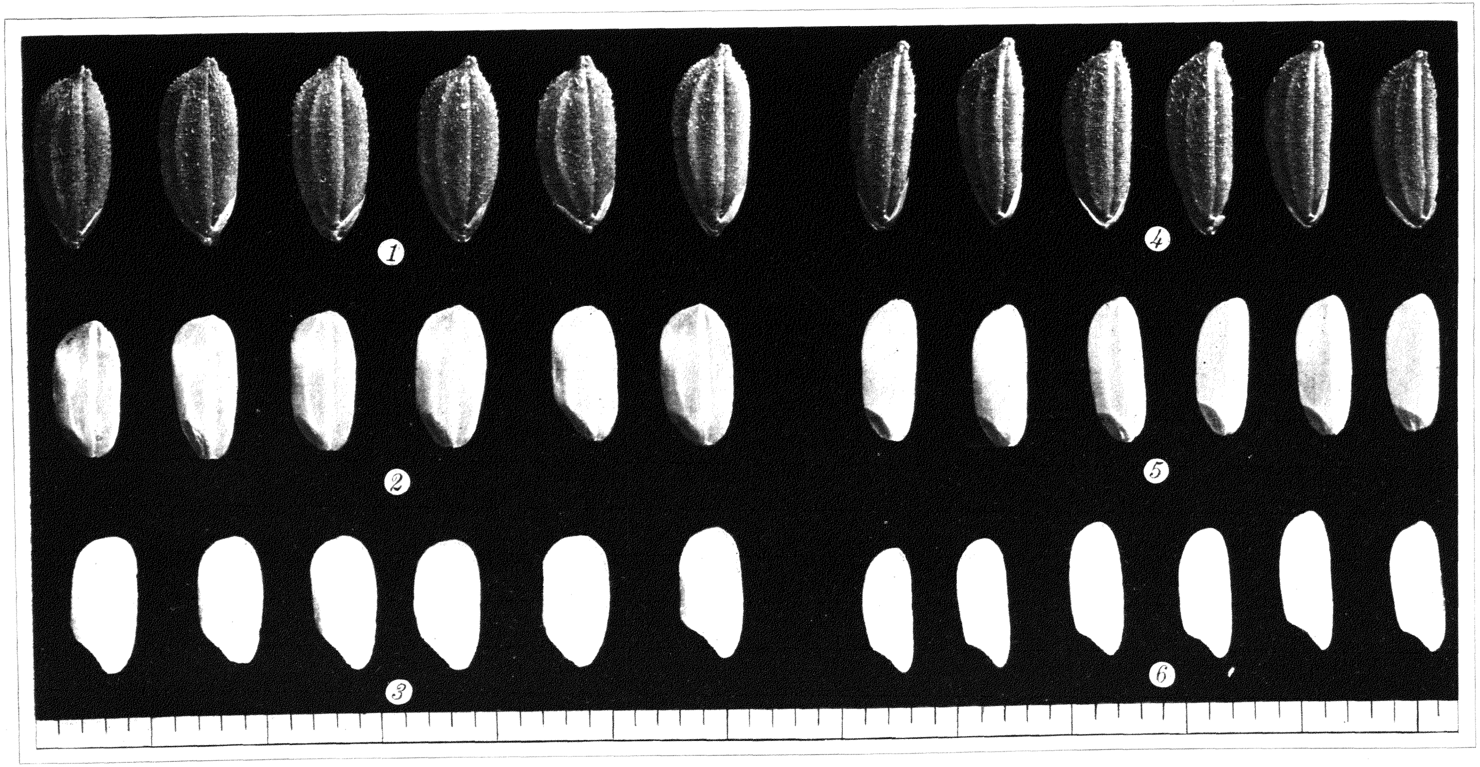

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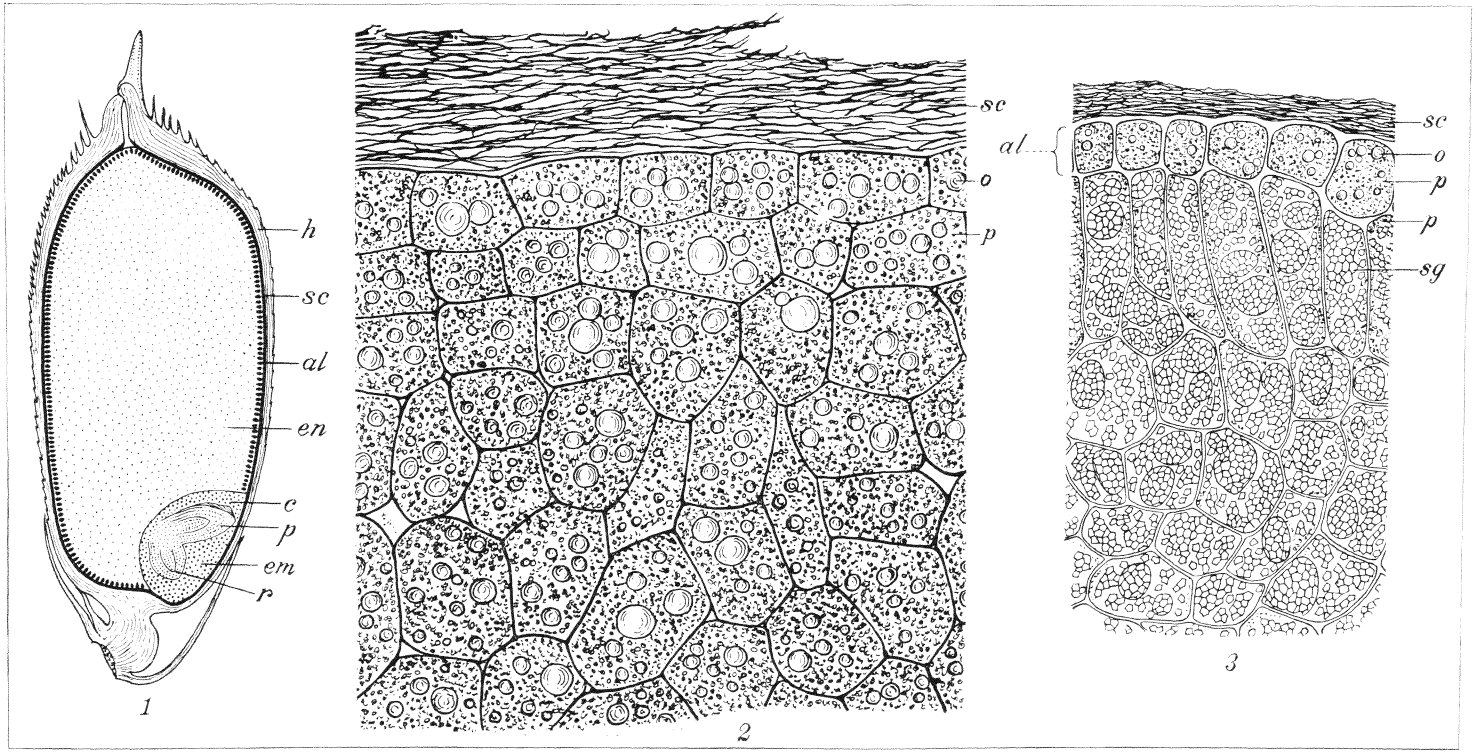

PLATE 7.

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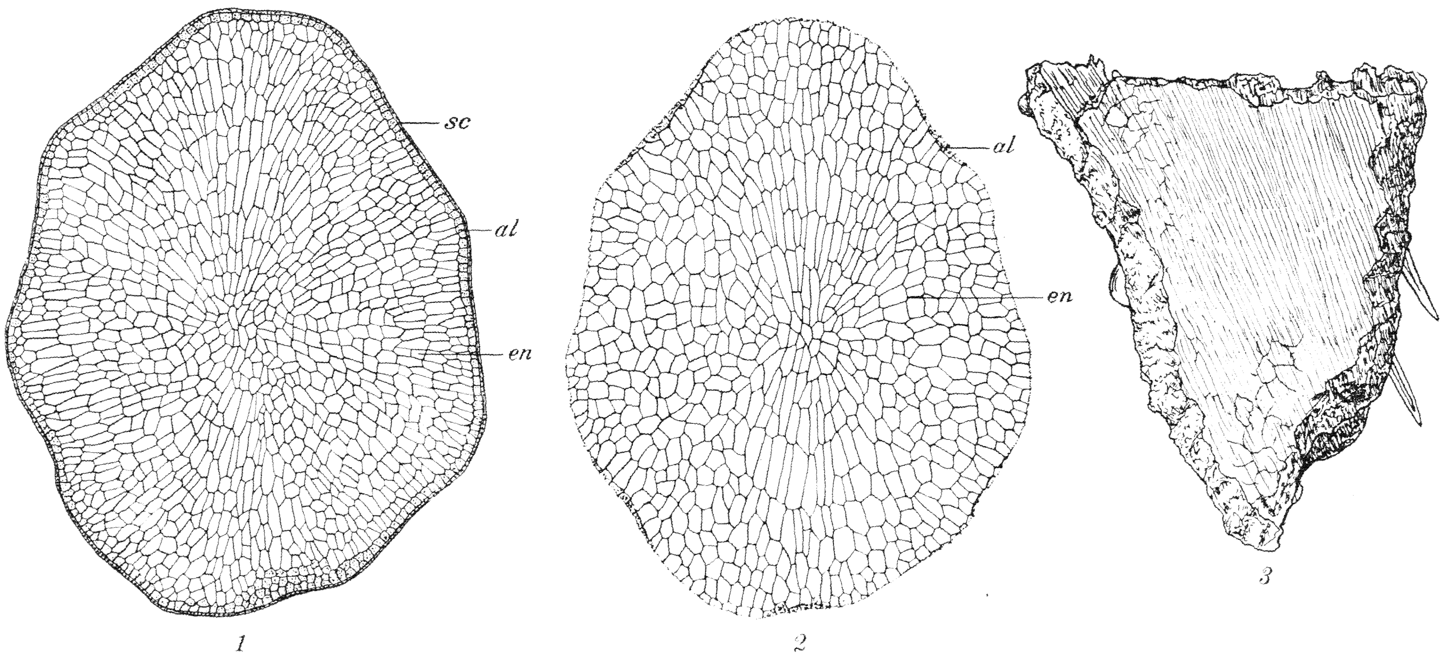
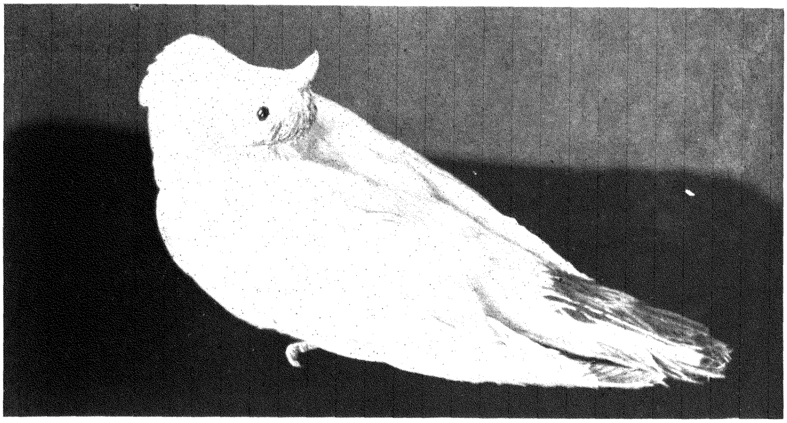


PLATE 8.



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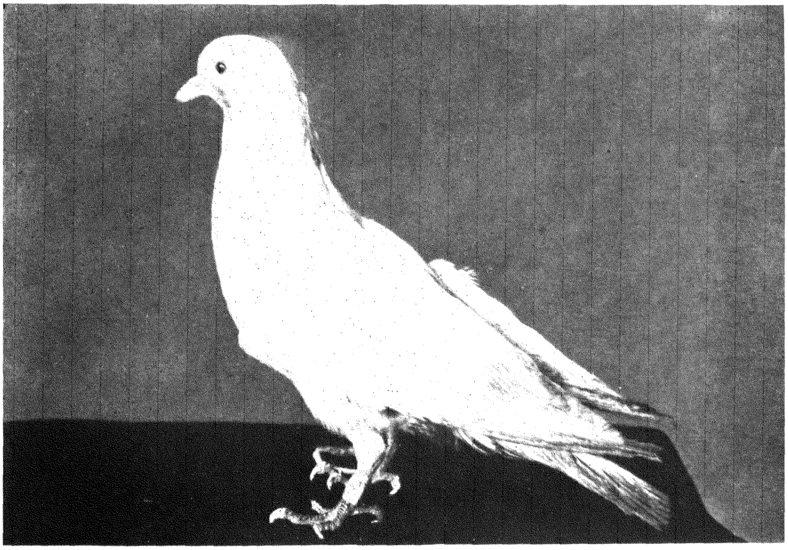

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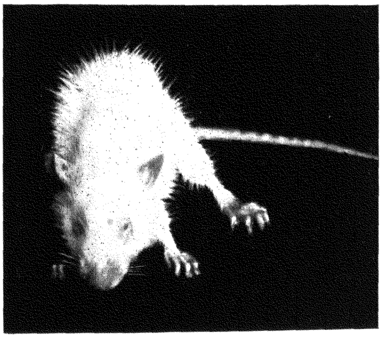

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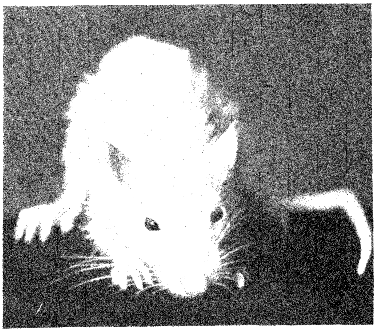

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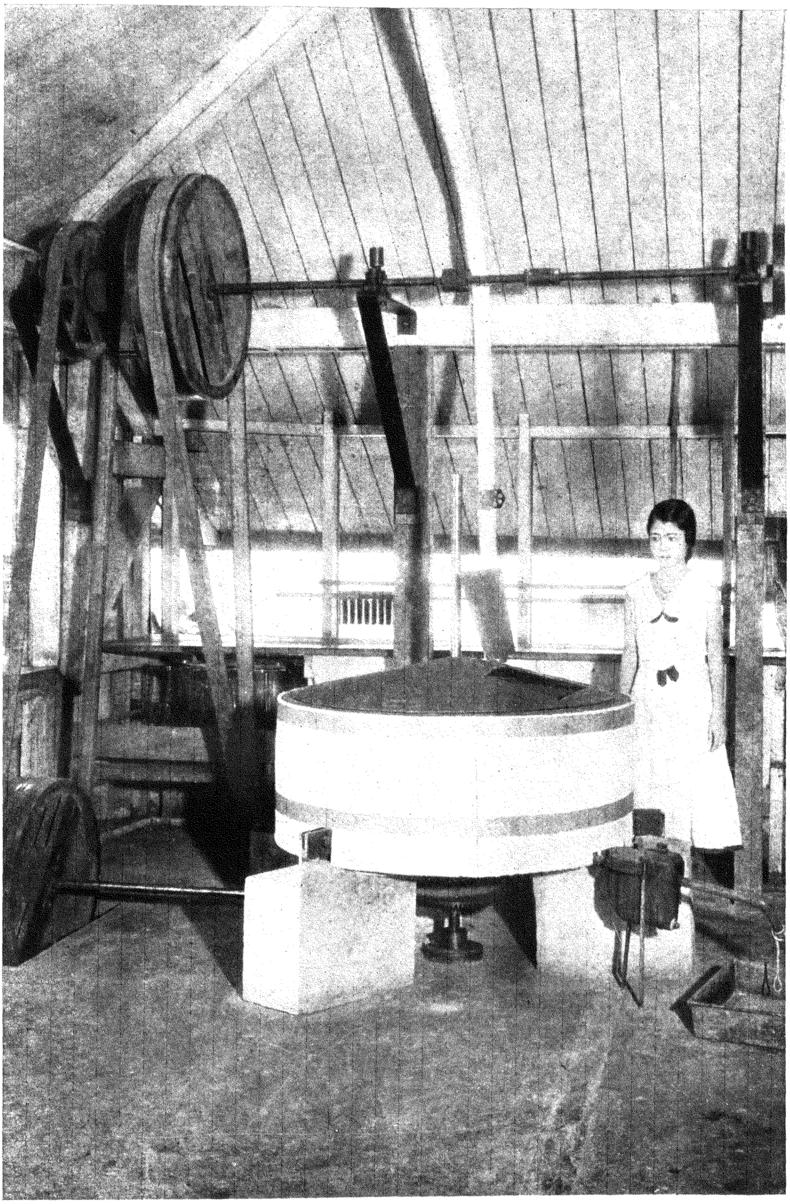

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THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 52 OCTOBER, 1933 No. 2

THE SOILS OF RENOVATED ABACÁ (MUSA TEXTILIS) FIELDS IN DAVAO AND THE REPORTED INFERIOR GROWTH OF THIS PLANT THEREIN

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and

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About the latter part of April, 1931, an inspection was made of certain abacá sections in Davao Province and first-hand information was gathered about the reported inferior growth and decreased fiber yield of abacá in renovated fields. The places particularly inspected were Bago and Daliao in the municipality of Davao, and the southern part of the municipal district of Guianga, which includes Mananbulan, Naming, Wangan, and Bayabas, where new and old plantations are found. Because of the drought, which lasted from January to the last week of April, abacá was dying in these places at the time of inspection, except in Bayabas, which is situated at a much higher altitude. The extent of the damage caused by the drought may be estimated at from 20 per cent in some plantations to 80 per cent in others. Of the three varieties; to wit, the Tangongon, the Maguindanaw, and the Bongolanon, which are most commonly grown in Davao, the Tangongon has been observed to be the most resistant to drought.

AGE OF PLANTATION AND FIBER YIELD

Yield in the first planting.—The first harvest of the fiber takes place eighteen months or two years after the seedling has been planted, depending upon the variety of abacá. The yield in the first harvest is very little, being only a few piculs per hectare. In the second harvest, or the third year after planting, the yield is already normal and increases to the fifth year; from the sixth to the ninth year, the yield is almost equal that of the third year; but from the tenth to the nineteenth year it actually decreases, until in the twentieth year in some fields, and in the twenty-fifth year in others, it is hardly worth while extracting the fiber, for the amount of it obtained per hectare, under normal conditions of supply and demand, barely leaves a margin of profit. When a field has reached this stage it becomes necessary to renovate it entirely.

The following data pertaining to three fields of different ages situated in Bago give an idea of the yearly production of fiber in the first planting. They were kindly furnished by the field superintendent of the Ohta Development Company.

Year.	Piculs per hectare.
Field E; 7 years old.	
Second	10
Third	50
Fourth	70
Fifth	70
Sixth	50
Field F; 20 years old.	
Second	10
Third	50
Fourth	
Fifth	70
Sixth	50
Seventh	70
Eighth	50
Ninth	40
Tenth	35
Eleventh to fifteenth	30
Sixteenth to twentieth	20

Field G, which is 25 years old, had produced the same average as field F from the third to the twentieth year, but in the twenty-fifth year it produced only an average of about 15 piculs per hectare.

Yields in the second planting.—The renovation of plantations which have been continuously grown with abacá for a score of years or more is a recent general practice. Of the several renovated fields inspected only two had abacá older than two years. Sufficient data, therefore, regarding the fiber yields in the second planting are as yet unavailable, although such information as was obtained was to the effect that in the third year of the second planting an average of 30 to 50 piculs could be obtained from every hectare.

Comparison of yields.—In comparing fiber yields two other factors, besides climate and soil, must be taken into consideration: one may be called consequential, and the other personal. The consequential factor is intimately connected with the fluctuation of the market price of the fiber. When this price is such that the planters receive a good margin of profit, the abacá fields are properly cared for, and as a consequence the stalks grow fast and large and a good number of suckers issue forth. This results in greater fiber yield per unit area. When the price of the fiber is low, or very low, as it has been for some time, the plantations receive but little, if any, care. This neglect causes retardation of growth, hinders the production of suckers, and results in decreased fiber yield.

The personal factor, which is one of management, causes a similar variation; that is to say, the growth of abacá and the increase or decrease in the fiber yield depends in a large measure upon the care given to the plantation.

It is clear from the foregoing information that in practically all instances a real comparison of yields between given periods for any one planting would be misleading, and if this is so, it would be much more misleading to compare the yields from one planting with those from another. In the present instance and at this time, at least, even if data for second plantings were available, this comparison could not properly be made, because:

(*a*) Records of yields for first plantings had not been kept as a rule, and some such yields as given were based on mere impression or belief. Presently, even if figures on yields for first plantings were available, still comparisons of these figures with the corresponding ones for second plantings could be made only several years afterwards, when the plants of the latter planting had completely or sufficiently recovered from the several effects of the last drought.

(*b*) Some of the varieties, like the Libuton and Baguisanon, which had constituted not an inconsiderable part of first plantings and which have been found to yield less and weaker fiber than the varieties now being planted, have not been replanted upon renovation of the plantation.

(*c*) Under the prevailing method of extracting the fiber, which was adopted a few years ago, in which method a small spindle machine takes the place of man power, more fiber goes to waste than by the old hand-pulling method.

THE CAUSE OF THE REPORTED INFERIOR GROWTH AT THE SECOND PLANTING

The fact, however, remains that, according to observation, the growth of abacá of the second planting compares unfavorably with that of the first. Here is a problem that calls for serious study on account of its important bearing upon the proper and successful maintenance of the abacá industry of the country.

In the absence of noticeable pathological causes and adverse weather conditions to which the inferior growth of abacá may be ascribed, and considering the length of time during which the soil has been in this crop before the renovation of a plantation takes place, it is but proper to trace the source of the trouble to the soil as the principal factor of growth. Therefore, field studies of the reaction and physical characteristics of the soils of representative fields, as well as laboratory determinations of the amounts, both total and available, of the essential plant food elements present in them have been made.

Description of soils.—As above stated, the districts where the present investigation was undertaken are Bago and Daliao in the municipality of Davao, and the southern part of the municipal district of Guianga. The soil from Bago to Daliao, and from Daliao north to Wangan, Guianga, is practically uniform, being mostly a brown or reddish brown loam grading into a friable clay loam underlain by a friable clay which becomes waxy with depth. The average depth of the soil is about 18 centimeters. The subsoil, to the depth of 90 centimeters, consists of two layers; the one immediately below the A horizon being a brown or reddish brown friable clay loam grading into a clay, and the other a waxy clay. The type occupies an undulating to rolling topography and is well drained.

The soil in Bayabas is lighter in texture, being a brown or yellowish brown loam, about 25 centimeters deep on the average, underlain by a reddish brown friable but heavier loam. Throughout the depth of 90 centimeters, the subsoil is almost uniform. This type occupies a rolling topography and is well drained.

In the section where the representative soil type is a loam on clay, ten fields were selected, as follows:

Field A.	In Naming, Guianga. Recently opened land.
Field B.	Adjoins Field A. A first planting, nearly 10 years old.
Field C.	In Wangan, Guianga. A recently cleared forest.
Field D.	Adjoins Field C. A first planting, about 3 years old.
Field E.	In Bago. A first planting, 7 years old.

Field F. In Bago. A first planting, 20 years old.
Field G. In Bago. A first planting, 25 years old.
Field H. In Daliao. A first planting, 25 years old.
Field I. In Daliao. A second planting, the abacá about 10 years old.
Field J. In Daliao. A third planting, the abacá is about 3 years old.

In the section where the representative soil type is a loam on loam four fields, all situated in Bayabas, Guianga, were chosen, as follows:

Field K. A first planting, about 1 year old.
Field L. A first planting, about 3 years old.
Field M. A first planting, about 3 years old.
Field N. A first planting, about 10 years old.

The reaction and plant food resources of the soils of the several fields.—The results of reaction tests in the field and of analyses of the soil and subsoil are presented in Tables 1 and 2. The top soil samples were taken to the depth of 15 centimeters, and the subsoil samples to the depth of 90 centimeters. The available phosphorus was determined by Frap's method, and the available potash, lime, and magnesia were determined by the base exchange method. The humus or organic carbon was not determined, because the soils are well supplied with organic matter owing to the fact that in harvesting the fiber about 98 per cent of the plant, consisting of leaves, nonfibrous parts of the pseudostem, and discarded portions of the *tuxie,* or fibrous strips, is left on the field and upon decomposition incorporated in the soil.

The pH values appearing in column 6 of Table 1 seem to show that, to the depth of 15 centimeters, soils of the same type vary in reaction depending on the length of time during which they have been in abacá, this reaction becoming, in general, less acidic as the field gets older; and that identical soils planted recently and for the first time, or in their virgin state, are acidic. Thus, the soil of field E, which is 7 years old, has a pH value of 6.2; but the soils of fields F and G, which are 20 and 25 years old, respectively, and situated in the same neighborhood as field E, have correspondingly pH values of 6.8 and 7.0. The soils of fields H, I, and J, which have been in abacá for not less than 25 years, give reactions that tend toward alkalinity. Again, the soil of field A, recently cleared virgin land, is more acidic than that of the adjoining field B, which is 10 years old. This decrease in acidity of the soils of the old fields may be due to the periodical incorporation in the soil of the organic matter which is left on the field as a result of the decomposition of those parts of the plant which are discarded during the harvest of the fiber;

for, as Stephenson[1] has found, "every organic treatment without lime has diminished the true acidity of the soil."

TABLE 1.—*Analysis of surface soil (15 centimeters deep) (moisture-free basis).*

Field.	District.	Age of field in—		Time elapsed between last stripping and soil sampling.	Soil reaction at time of sampling.[a]
		First planting.	Second planting.		
		Years.	*Years.*	*Weeks.*	*pH.*
A	Naming, Guianga	([b])			6.4
B[c]	do	10		3	6.8
C	Wangan, Guianga	([b])			6.4
D[d]	do	3		3	6.4
E	Bago, Davao	7		6	6.2
F	do	20		12	6.8
G	do	25		4	7.0
H	Daliao, Davao	25		3	7.2
I	do		10	5	7.2
J	do		([e]) 3	3	6.8
K[f]	do	1			4.2
L	Bayabas, Guianga	3		$\frac{2}{7}$	5.0
M	do	3		4	6.4
N	do	10		5	6.0

Field.	Total plant food.					Available plant food.			
	(N)	(P_2O_5)	K_2O	CaO	MgO	P_2O_5	K_2O	CaO	MgO
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
A	0.22	0.16	0.33	0.83	0.51	0.0029	0.1727	0.457	0.159
B[c]	.25	.17	.29	.81	.51	.0021	.1242	.311	.246
C	.24	.22	.25	.69	.53	.0022	.1649	.272	.213
D[d]	.24	.26	.21	.69	.53	.0031	.1422	.275	.129
E	.21	.17	.44	.80	.46	.0016	.1417	.441	.121
F	.22	.26	.63	1.66	.56	.0083	.1017	.643	.154
G	.20	.22	.40	.81	.66	.0021	.1238	.360	.126
H	.23	.19	.39	.90	.80	.0022	.0765	.475	.091
I	.26	.29	.37	.98	.67	.0026	.1184	.502	.080
J	.26	.23	.53	.97	.82	.0029	.1220	.476	.093
K[f]	.27	.20	.38	.52	.28	.0013	.1475	.139	.141
L	.40	.21	.39	.92	.23	.0015	.1528	.282	.135
M	.26	.19	.40	.73	.42	.0016	.0979	.348	.146
N	.27	.11	.34	.46	.44		.1056	.247	.183

[a] Determined colorimetrically using the La Motte soil testing set.
[b] Recently cleared land.
[c] Contiguous to and the same soil as A.
[d] Contiguous to and the same soil as C.
[e] Third planting.
[f] Contiguous to and same soil as L.

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[1] Stephenson, R. E., The effect of organic matter on soil reaction, Soil Sci. 12 (1921) 145.

TABLE 2.—*Analysis of subsoil (15 to 90 centimeters) (moisture-free basis).*

Field.	Reaction at time of sampling.	Total plant food.				
		N	P_2O_5	K_2O	CaO	MgO
	pH.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
A	5.0	0.079	0.150	0.26	0.44	0.37
B	------	------	------	------	------	------
C	6.4	.096	.220	.28	.48	.26
D	5.4	.092	.230	.31	.38	.29
E	5.2	.094	.067	.26	.53	.46
F	6.4	.074	.073	.68	.76	.51
G	6.2	.095	.110	.47	.44	.51
H	6.6	.086	.120	.22	.62	.65
I	6.8	.096	.130	.27	.62	.55
J	5.6	.092	.160	.19	.53	.86
K	4.4	.160	.200	.31	.52	.42
L	4.6	.130	.130	.30	.81	.47
M	5.4	.120	.092	.32	.43	.34
N	4.8	.045	.076	.19	.20	.08

The table incidentally seems to show that the loam on loam soils of Bayabas, which are situated at a high altitude, are more acidic than the virgin loam on clay loam soils found at the much lower level, in Bago and Daliao. The same appears to be true in the case of the subsoils, as shown in Table 2.

It might perhaps be supposed that the condition or state of decomposition of the plant wastes left on the fields incidental to the extraction of the fiber would influence the aforesaid reactions, but a correlation of the data in column 2, Table 2, and in column 5, Table 1, with those in column 6 of the latter table does not seem to warrant this supposition.

As regards the plant food constituents in the soils of the several fields investigated, the data in the tables are not, for any one kind of these constituents, comparable with one another, because nothing is known as to the amounts of them originally present. On the other hand, the figures show that, for the same soil type where the growth of abacá is to all appearances the same, in both the soil and the subsoil the quantities of essential plant food elements, except nitrogen, differ rather significantly for the several fields, and such differences have no relation to the ages of these fields. The figures seem also to show that, regardless of the age of the plantation, these quantities are adequate for the normal growth of the crop, if the analyses of the soils of fields A and G, which are recently cleared virgin lands, or those of fields B, F, and K, which are 10, 7, and 1 years old, respectively, are taken as the criterion. Judged by the same standard the available plant nutrients seem likewise to be adequate, but just as in the case of the total, they do not correlate with the ages of the fields, as disclosed by a cursory inspection of the data in the last four columns of Table 1. Such lack of correlation may perhaps be due partly to the fact that a great proportion of the nutrients existing in available form in the soil were derived from the unequal amounts of plant wastes which were left and allowed to decompose on the field incidental to the extraction of the fiber. Some importance should, however, be attached to the comparatively very low amounts of available magnesium in the oldest fields (H, I, and J), which may be one of the limiting factors of growth in the second planting.

It should be noted in connection with this discussion that the amounts of essential plant food elements removed from a hectare of soil as fiber constituents in the twenty years during which the crop of the first planting is supposed to last, seem to be unimportant, as will be shown. When fiber of good cleaning grade is produced, as it is generally produced in Davao, practically 98.5 per cent of the above ground part of the plant remains on the field and only 1.5 per cent is removed as fiber. Analysis of abacá fiber of excellent cleaning made in the Bureau of Science shows that this grade contains, on an average, 0.080 per cent nitrogen (N), 0.012 per cent phosphoric anhydride (P_2O_5), 0.428 per cent potash (K_2O), and 0.164 per cent calcium oxide (CaO). Now, fiber of excellent cleaning is only one grade higher than fiber of good cleaning, so that for the purpose of having an idea of how much plant food has been removed as fiber constituents from a hectare of soil for a given period of time these values may be conveniently used. The production in twenty years, as stated elsewhere in this paper, is about 695 piculs, or 43,933 kilos of fiber of good grade, per hectare. Based on the above percentages, this weight of fiber has removed from a hectare of soil 35.146 kilos of nitrogen, 5.272 kilos of phosphoric anhydride, 188.034 kilos of potash, and 72.050 kilos of calcium oxide. These quantities of nutrients constitute, with the exception of potash, but a very small fraction of even the available plant food resources in a hectare of any one of the soils herein described after twenty or twenty-five years of cropping, and can be readily replaced by a ton of fertilizer having the composition of 3.51 per cent nitrogen, 0.53 per cent phosphoric acid, 18.80 per cent potash, and 7.03 per cent lime.

It can be seen from the foregoing that an explanation of the cause of the reported inferior growth of abacá of the second planting based upon the insufficiency of the plant food elements in the soil would be unsatisfactory, but that field observation and laboratory results tend to show that this inferior growth may be due to the decreased acidity or to a reaction change towards alkalinity of the soil as a consequence of its long continuous cropping. However, plot experiments should be carried on over a period of years to supplement these observations on the relationship between abacá growth and the age of plantation.

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Thanks are due to Mr. Tsutaya, of the agricultural department of the Furukawa Plantation Company, and to the officials and employees of the Ohta Development Company, particularly to U. Kojima and the gentleman in charge of the plantation in Bago, Davao, for valuable information and assistance given in the field.

EXPERIMENTAL INQUIRY INTO THE TRANSMISSION OF RAT-BITE FEVER AMONG RATS: PART I

By SHIZUKA ARIMA[1]

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Rat-bite fever is essentially an epizoötic of rats. In a great majority of human cases the history is too definite to leave any doubt as to the manner of transmission of the disease from rats to humans. The name of the disease has been coined accordingly. Yet cases of human rat-bite fever have been noted by experienced physicians in which the history was obscure or indefinite with regard to rat bite, an occurrence that could remain unnoticed by any person.

Experimental evidence teaches us (*a*) that highly susceptible rodents may live peacefully along side of an infected mate for a long time without contracting rat-bite fever, but that an infected rodent will inevitably convey the disease to his healthy mates by bite if a combat takes place among these animals; (*b*) that the disease, in its acute stage, may produce abortion among rodents, but the evidence as to congenital transmission of the disease has been uniformly negative; (*c*) that rat-bite fever assumes a chronic form among rodents in which a condition of latency, so to speak, may be reached, when the parasites can no longer be found by microscope in the blood or in the tissues, but their presence in the internal organs can be demonstrated by transfers of the organs to normal, susceptible, experimental animals. These are every-day experiences with the disease in the laboratory.

As far as we know, the disease is not transmitted from man to man, and this mode of spreading is not probable in rat-bite fever. The disease is maintained and propagated among and by rats..

The only mode of transmission of the disease among these animals that is positively known and is the easiest to accomplish under laboratory conditions is that by direct bite. This mode alone of conveying the disease explains satisfactorily the prevalence of rat-bite fever among rats if one considers the enormous fertility of these animals and the frequent combats among them, either in the struggle for food or for male supremacy in a territory they inhabit.

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[1] Surgeon, Lieutenant Commander, Imperial Japanese Navy.

Of other, less-common means of propagation of this disease among rats the bloodsucking insects, particularly fleas, and the ingestion of blood and organs of recently slaughtered antagonists occur to one's mind as most likely to play a part.

Urged by these considerations and hoping that the study of transmission by flea bite in particular might throw some light on the provenience of obscure human cases with negative rat-bite history, we undertook the three sets of experiments that are the subject of this communication.

First some information concerning the viability of the particular strain of spirochætes within the flea's body under the actual conditions of experiment was deemed essential. This question was considered in the first experiment.

An attempt to transmit the disease by the interrupted feeding of fleas on an infected host and subsequently on a healthy susceptible animal was the subject of the second experiment.

Susceptible normal experimental animals were allowed to feed on the blood and organs of infected ones in the third experiment, in order to inquire into the transmission of the disease by ingestion.

VIABILITY OF SPIROCHÆTA MORSUS MURIS ON OR IN THE BODY OF INFECTED FLEAS

TECHNIC

Fleas, secured from outside the laboratory, were allowed to take a full meal of blood, rich in spirochætes at the time of experiment, by sucking from an infected guinea pig. The fleas were put away under the best conditions available and from time to time samples of fleas were crushed, examined under dark-field microscope, stained slide, and inoculation to susceptible normal animals. The details and results are summarized in Tables 1 and 2. It may be mentioned in connection with these experiments that the time of the fleas, meals varied considerably. Although the length of mealtime was noted as necessary information for the arrangement of experiments in which interrupted feeding was used, it was not considered in the interpretation of the results. The lifetime of the captive fleas was often annoyingly brief. Thus it happened that at the expiration of the periods of time, as given in the tables, the fleas have been dead for some time. For this reason the time of exposure of spirochætes in or on the body of fleas was limited to two hours in the animal experiment. It is believed, however, that the upper time limit of viability of *Spirochæta morsus muris* was reached.

Microscopic examination of infected fleas crushed and examined at a definite period of time revealed the presence of spirochætes typical in shape, size, and movement within one hour after feeding. After and including that period of time the spirochætes could no longer be discerned with certainty. Nonmotile, swollen, irregularly round or beaded forms were encountered under the dark-field. In such cases stained slides were at times more satisfactory.

The results of inoculation of crushed, infected fleas into guinea pigs agree with those obtained by microscopic examination. Animals inoculated with emulsion of infected fleas that were killed, crushed, and injected within one hour after they had fed on infected blood showed unmistakable signs of infection with *Spirochæta morsus muris.* Fleas that were crushed and inoculated to guinea pigs later than one hour after feeding failed to provoke symptoms of the disease.

ATTEMPT TO TRANSMIT RAT-BITE FEVER FROM ANIMAL TO ANIMAL BY FLEA BITE

TECHNIC

In each of five trials an infected guinea pig that showed sufficient number of spirochætes in the blood to be easily found by the dark-field microscope was selected as a donor on which fleas were fed. As soon as the flea had ingested a sufficient amount of the donor's blood to be noticeable to the naked eye the feeding was interrupted and the flea was placed on a normal recipient guinea pig to complete its meal. It was not always possible to induce the fleas to reassume feeding on the fresh guinea pig, and unless they did so within a short time they were discarded. Thus, only smoothly proceeding experiments are herewith reported, which are only a fraction of all the trials. The details of this experiment are summarized in Table 4.

With the exception of fever none of the symptoms of experimental rat-bite fever have been noticed in the animals that were repeatedly bitten by infected fleas under otherwise favorable conditions.

To carry the proof as far as present knowledge of the disease and technical procedures make it possible, the animals that had been repeatedly bitten by infected fleas were sacrificed and their spleens and lymphatic glands inoculated separately into fresh normal guinea pigs. These remained healthy and negative as to symptoms of rat-bite fever.

ATTEMPT TO TRANSMIT RAT-BITE FEVER BY FEEDING BLOOD AND ORGANS CONTAINING SPIROCHÆTA MORSUS MURIS

TECHNIC

Infected blood and organs of a guinea pig were removed and immediately given to white mice as food. The presence of spirochætes was confirmed by dark-field examination. The white mice licked the blood and organs as soon as offered to them. However, they did not eat the organs. The feeding of the blood was repeated on two successive days, and on the third day the organs were fed to the same animals that ingested the infected blood previously. Blood was examined daily for spirochætes for three weeks but none were found.

The animals were sacrificed and their organs inoculated into a guinea pig. Blood was examined daily, and the fever curve was drawn.

Four days after the inoculation of the guinea pig there developed at the place of inoculation an induration, but spirochætes were not found in the serum obtained from the lesion, which disappeared in ten days. The temperature curve was not typical of the rat-bite fever and the animal remained alive.

The result of this experiment is negative. However, it is not conclusive, because the animals did not eat the organs.

SUMMARY

Experimental inquiry was conducted into the possibility of the transmission of rat-bite fever from rodent to rodent by flea bite and by ingestion of infected blood and organs of rodents, dead of the disease. As a preliminary experiment the viability of *Spirochæta morsus muris* in the flea's body was investigated.

Laboratory animals were used and local Manila strains of the spirochæte were employed.

DISCUSSION AND CONCLUSIONS

For the purpose of proper interpretation of the findings some reference to previous work on Manila rat-bite fever must be made.

The Manila strains of *Spirochæta morsus muris* have been found to be very virulent, invariably producing death in guinea pigs, rabbits, and monkeys. The viability of the Manila strains within the animal's blood when removed from the body has been found to be much longer than that in the body of fleas. As these tests have been performed with the same strains and in the same laboratory they bear comparison. Considering previous findings with ours certain conclusions can be drawn, as follows:

1. The viability of *Spirochæta morsus muris* within the flea's body is of very short duration.
2. There is no evidence that a progressive multiplication takes place within the body of an infected flea. The evidence is to the contrary.
3. The part of fleas in spreading and maintaining rat-bite fever among rats or in transmitting the disease to humans is insignificant.

TABLE 1.—*Showing the results of microscopic investigation of crushed fleas.*

[+, Spirochæte found; relative number of spirochætes found is indicated by number of pluses.]

Examination No.	Hours after feeding.	Results.		Remarks.
		Dark-field.	Staining.	
1	([a])	++	++	Form, size, and motion are typical.
2	([a])	+++	+++	
3	([a])	+++	+++	
1	0.5	++	++	Do.
2	0.5	++	++	
3	0.5	++	++	
1	1.0	Doubtful	Doubtful	Organism thick, windings are not so typical, motility is not active.
2	1.0	do	do	
3	1.0	+	+	
1	2.0	Very doubtful	Doubtful	
2	2.0	Not found	Not found	
3	2.0	do	do	
1	4.0	Not found; flea dead	Doubtful	Windings lost; looks like stick form.
2	4.0	do	do	
3	4.0	Not found; flea living	Not found	
1	8.0	Not found; flea dead	Doubtful	In dark-field; in shape resembles *Spirochæta morsus muris*, but is nonmotile.
2	8.0	do	do	
3	8.0	do	do	
1	16.0	do	Not found	
2	16.0	do	do	
3	16.0	do	do	
1	20.0	do	do	
2	20.0	do	do	
1	24.0	do	Doubtful	Curved, beaded organism found on stained slide made from crushed dead flea, 24 hours after feeding. The organism resembled in general shape and size *Spirochæta morsus muris*.
2	24.0	do	do	

[a] Examined immediately after feeding.

4. This explains the character of endemics and outbreaks of the disease, which unlike plague occurs in the form of isolated cases.

5. Our experiments concerning the transmission of rat-bite fever by ingestion are not conclusive.

TABLE 2.—*Showing the results of experiments concerning the viability of Spirochæta morsus muris in the body of fleas.*

[Test for viability performed by injection of crushed fleas to susceptible animals. All fleas alive; +, found; —, not found.]

Recipient guinea pig No.	Fleas inoculated.	Time after feeding the fleas.	Manifestations of the disease in guinea pig.		
			Fever.	Local lesion.	Spirochætes.
M-176	May 6, 1932	Immediately	+	+	+
M-181	May 6, 1932	One hour	+	—	+
M-182	May 6, 1932	Two hours	—	—	—
M-186	July 30, 1932	Immediately	+	+	+
M-189	July 30, 1932	One hour	+	—	—
M-188	July 30, 1932	Two hours	—	—	—

TABLE 3.—*Showing the length of time of feeding of fleas on donor (feeding) and on recipient (biting).*

Date of experiment.	Flea No.	Feeding on donor.	Biting recipient.	Recipient No.
		Mins.	*Mins.*	
May 6, 1932	F-1	2	1	M-174
May 6, 1932	F-4	1	1	M-174
May 6, 1932	F-8	2	0.5	M-174
June 12, 1932	F-2	5	0.5	M-174
June 12, 1932	F-5	2	4	M-174
June 12, 1932	F-9	2	5	M-174
July 30, 1932	F-3	3	7	M-174
July 30, 1932	F-5	3	5	M-174
July 30, 1932	F-8	1	6	M-174
August 9, 1932	F-1	2	1	M-174
August 9, 1932	F-5	2	1.5	M-174
August 9, 1932	F-6	2	1	M-174
August 8, 1932	F-1	2	4	M-190
August 8, 1932	F-4	3	5	M-190
August 8, 1932	F-4	3	5	M-190
September 3, 1932	F-2	2	3	M-190
September 3, 1932	F-2	2	3	M-190
September 3, 1932	F-6	3	3	M-190

TABLE 4.—*Showing the results of experiments concerning transmission of rat-bite fever from animal to animal by means of flea bites.*

[Test performed by interrupted feeding of fleas on infected and then on normal experimental animals.]

Date of experiment.	Guinea pig No. (recipient).	Manifestations.		
		Fever.	Lesion.	Spirochætes.
May 6, 1932	M-174	—	—	—
June 12, 1932	M-174	+	—	—
July 30, 1932				
August 9, 1932	M-174	+	—	—
August 8, 1932	M-190	+	—	—
September 3, 1932	M-190	+	—	—

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STUDIES ON THE WEIGHTS OF VISCERAL ORGANS IN FILIPINOS[1]

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In a series of papers we are reporting our studies on the weights of the principal visceral organs of normal and pathological cases in relation to age, length of body, and body weight with a view to establishing standards for Filipinos.

Bean (1) was the first to study the weights of vital organs in Filipinos. In his analysis of the various human types, he found that the organs were small in the slender type called hypermorph and large in the stocky type called mesomorph, or in the hypomorph, the infantile adult. Supplementing his studies in Manila with further data in the United States, he pointed out the difference in size of the organs in relation to such factors as race, sex, stature, nutrition, age, and disease. Nañagas (2) also reported a study on the dimensions of kidneys in Filipinos but without reference to weights.

Sitsen (3) reported his investigations on the weights of several organs among the Malays of Java. His study is particularly important to us for purposes of comparison since the Filipinos are predominantly Malays. Castor, (4) in India, reported the weights of organs of East Indians and Burmans.

In Europe and America investigations of this nature are profusely quoted in standard works of anatomy and pathology by well-known authors, including Jackson, (5) Piersol, (6) Cunningham, (7) Orth, (8) and Vierordt. (9) Scammon (10) cited Muller, Gundobin, Bovaire, Nicholl, Lorey, Notori, Oppenheimer, Harley, Kowalski, Thoma, Starck, and others, in their reports on the weights of various visceral organs in Occidental races.

Our studies are based on more than 11,000 necropsy records of the Department of Pathology and Bacteriology of the University of the Philippines, from 1907 to 1924, and more than 1,000 cases of the Department of Legal Medicine of the same university, from 1925 to 1931. We here record our appreciation of the help of these two departments in this matter.

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[1] Read before the Second Philippine Science Convention, February 16, 1933.

During the performance of post-mortems all important organs were weighed and measured in the fresh state previous to cutting and examination and before placing them in preservatives. The weights were taken continuously by the same persons during the period included in our series.

We are reporting our studies in several papers. This first paper is intended to serve as an introduction. The second will be confined to a study of the weights of normal organs in infants and children from birth to adolescence. The third paper will be concerned with the weights of organs in adult Filipinos at different ages. The fourth will deal with the weights of organs in relation to length and body weight, and the fifth and last paper of the series will discuss the weights of organs in pathological conditions.

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NORMAL WEIGHTS OF VISCERAL ORGANS IN FILIPINO CHILDREN[1]

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ONE TEXT FIGURE

Information on the weights of normal visceral organs in children is of importance not only for academic study but also in actual practice, especially in medicolegal and court investigations. The knowledge of normal weights of organs at different ages finds practical application in the determination of the probable age of unidentified children, victims of accidents or foul play. This knowledge will corroborate and supplement other findings; such as the external measurements of the body, the number and condition of the teeth, and other developmental characteristics.

Furthermore, the knowledge of the normal weights of organs would be of service as a basis for comparison in deciding pathological variations in the weights of these same organs.

The present paper will be confined to the determination of the weights of normal visceral organs in infants and children from birth to adolescence. These include stillborn, newborn, infants, and children under 16 years of age that died due to violence or accidents.

The stillborn and newborn included in this study were full-term babies that died as a result of manipulation during delivery. The other children died by drowning, falls, automobile accidents, extensive burns, and other violent influences. These cases were normal children previous to their death, suffering from no previous pathologic condition that might in any way affect the weight of the organs. In all cases, death occurred soon after the accident so that not much change could have taken place in the visceral organs to materially alter the weights. In this group we have collected 338 cases—243 males and 95 females.

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[1] Read before the Second Philippine Science Convention, February 16, 1933.

RESULTS OF INVESTIGATION

Tables 1 to 10 show summaries of our findings and give the absolute average weights of normal visceral organs in Filipino children classified according to age at the time of death. From these tables it will be seen that the heart, spleen, liver, pancreas, and kidneys increase in weight more rapidly during the first year than during any other age. Bean(1) also observed the rapid growth of each organ after birth, but he also mentioned a second period of rapid growth a few years later, and a third period about puberty. In our studies, however, we observe that in general after the first year of age, the yearly gain in weight appears to be more or less constant, and may be represented by the slope of a straight line whose empirical formula can be determined by graphic method.

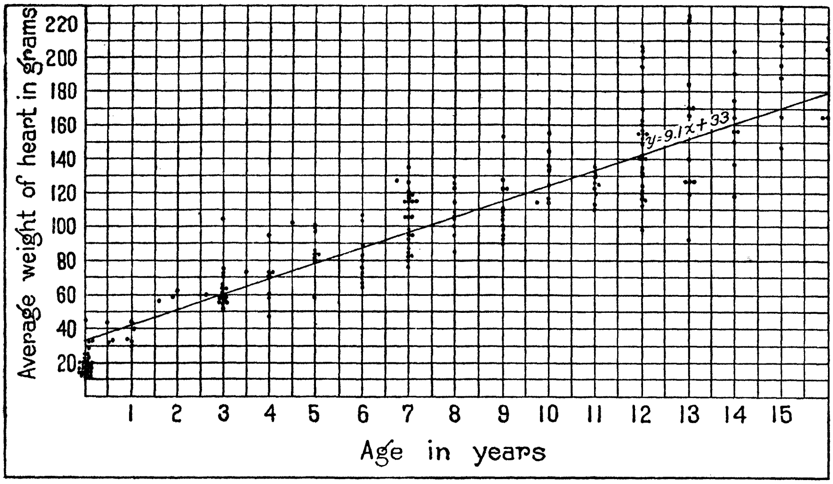

FIG. 1. Graph of average normal weights of the heart in male Filipino children.

For illustration we present in fig. 1 a graph made by plotting the individual weights of the heart in male children at different ages. Each dot in the figure represents the observed weight of the heart for each individual case. The solid line represents the approximate curve of the averages of these observations.

It will be noted that the curve for the males shows an increasing weight of a more or less constant rate after the age of 1 year, and follows the approximate course of a straight line which may be expressed by the equation, $y = 9.1x + 33$, where

y is the weight of the heart in grams, x the age of the child in years, 9.1 (slope of the line) the yearly gain in weight of the heart in grams, and 33 (y-intercept of the line) a constant.

Similarly, the curves for the other organs have been found to approximate straight lines and their equations have been determined by us. The equations for all the organs studied are as follows:

Heart:
  Male, $y = 9.1x + 33.$
  Female, $y = 8.6x + 32.$
Spleen:
  Male, $y = 3.8x + 30.$
  Female, $y = 3.8x + 24.$
Liver:
  Male, $y = 51x + 240.$
  Female, $y = 50x + 220.$
Pancreas:
  Male, $y = 4.2x + 11.$
  Female, $y = 4.2x + 8.$
Suprarenal gland, right:
  Male, $y = 0.15x + 3.4$
  Female, $y = 0.15x + 3.1.$
Suprarenal gland, left:
  Male, $y = 0.17x + 3.6.$
  Female, $y = 0.16x + 3.4$
Kidney, right:
  Male, $y = 4.5x + 24.$
  Female, $y = 4.2x + 24.$
Kidney, left:
  Male, $y = 4.7x + 25.$
  Female, $y = 4.4x + 25.$

The above formulæ, however, are not applicable to children less than 1 year of age, for in these cases the gain in weight of the organs is more rapid. For instance, in male infants the weight of each of these organs nearly doubled itself in the first six months and nearly trebled at the end of the first year. In the female infants we are unable to state definitely the increase in the rate of growth due to insufficient number of cases in the series.

The suprarenal glands, unlike the other organs, tend to decrease in weight during the first six months in both sexes, but later the gain in weight becomes also constant and uniform.

It will be noted from Tables 1 to 10 that the visceral organs of the males are uniformly heavier than those of the females for all ages. Comparing with tables of Vierordt(2) it is observed that Filipinos are born with slightly lighter organs than Europeans. After birth, however, it is interesting to note that the absolute weights of the principal visceral organs in Filipino children, with the exception of the kidneys, compare favorably with those of Occidentals, especially in their early years. These findings are verified by the reports of Muller, Gundobin, Bovaire, Nicholl, Lorey, Notori, Oppenheimer, Harley, Kowalski, Thoma, Starck, and others, cited by Scammon.(3)

TABLE 1.—*Average normal weights of the heart in Filipino children.*

Age.	Male.			Female.		
	Cases.	Heart, average weight.	Probable error.	Cases.	Heart, average weight.	Probable error.
Yrs.		*g.*	*g.*		*g.*	*g.*
Stillborn	9	18.22	±1.40	9	20.11	±0.79
Newborn	28	18.04	±0.83	8	17.38	±0.61
Under 1	10	37.80	±4.25	5	24.60	±1.91
1–2	8	45.63	±2.47	7	51.00	±1.96
2–3	2	61.00	----------	7	49.71	±1.80
3–4	20	63.75	±1.72	9	62.89	±3.34
4–5	11	73.45	±3.48	5	75.00	±3.98
5–6	10	81.00	±4.11	8	83.88	±3.60
6–7	12	83.92	±3.60	3	90.67	----------
7–8	26	103.62	±2.06	6	80.33	±5.35
8–9	9	109.22	±3.13	4	100.25	----------
9–10	15	110.67	±3.32	5	97.80	±4.09
10–11	7	135.00	±3.98	2	125.50	----------
11–15	76	159.32	±3.48	17	167.00	±5.92

TABLE 2.—*Average normal weights of the spleen in Filipino children.*

Age.	Male.			Female.		
	Cases.	Spleen, average weight.	Probable error.	Cases.	Spleen, average weight.	Probable error.
Yrs.		*g.*	*g.*		*g.*	*g.*
Stillborn	7	9.71	±1.16	7	8.43	±0.71
Newborn	24	6.92	±0.39	9	10.22	±0.99
Under 1	8	23.88	±3.74	6	18.17	±1.98
1–2	8	40.75	±3.65	7	38.14	±2.18
2–3	2	62.00	----------	6	39.17	±2.33
3–4	19	50.74	±2.26	8	38.25	±1.47
4–5	10	42.80	±2.03	7	40.87	±2.28
5–6	9	45.89	±2.03	10	51.20	±3.04
6–7	11	42.00	±2.21	3	45.67	----------
7–8	25	59.00	±2.45	7	36.57	±3.49
8–9	10	67.40	±5.50	5	61.20	±6.61
9–10	13	59.54	±2.31	1	54.00	----------
10–11	8	63.38	±6.15	3	84.67	----------
11–15	73	86.52	±2.67	17	104.53	±7.16

TABLE 3.—*Average normal weights of the liver in Filipino children.*

Age.	Male.			Female.		
	Cases.	Liver, average weight.	Probable error.	Cases.	Liver, average weight.	Probable error.
Yrs.		*g.*	*g.*		*g.*	*g.*
Stillborn	6	138.17	± 8.26	7	148.00	± 7.00
Newborn	18	104.17	± 4.33	8	123.63	± 5.79
Under 1	8	242.00	±32.36	5	165.60	±15.49
1–2	5	305.80	±14.37	8	342.75	±37.33
2–3	2	401.00		7	351.14	±19.16
3–4	15	430.53	±12.58	8	363.00	±14.65
4–5	8	435.63	±16.90	4	510.75	
5–6	9	580.89	±29.68	6	515.00	±22.42
6–7	11	543.64	±26.54	1	675.00	
7–8	19	625.42	±20.12	5	489.00	± 19.72
8–9	10	704.50	±26.21	5	686.00	±36.88
9–10	10	624.60	±18.76	4	673.25	
10–11	6	805.17	±43.15	3	628.00	
11–15	60	893.55	±16.31	15	865.60	±45.91

TABLE 4.—*Average normal weights of the pancreas in Filipino children.*

Age.	Male.			Female.		
	Cases.	Pancreas, average weight.	Probable error.	Cases.	Pancreas, average weight.	Probable error.
Yrs.		*g.*	*g.*		*g.*	*g.*
Stillborn	2	1.50		1	4.00	
Newborn	6	3.17	±0.19	3	4.00	
Under 1	2	11.00				
1–2	1	17.00		3	17.67	
2–3				1	22.00	
3–4	4	28.75		1	27.00	
4–5				2	22.00	
5–6	1	29.00		2	27.00	
6–7	2	36.00		1	30.00	
7–8	8	46.25	±2.70	2	47.00	
8–9						
9–10	3	43.33		2	53.50	
10–11	5	56.60	±3.68	2	49.00	
11–15	15	60.27	±2.47	5	63.80	±4.16

TABLE 5.—*Average normal weights of both suprarenals in Filipino children.*

Age.	Male.			Female.		
	Cases.	Both suprarenals, average weight.	Probable error.	Cases.	Both suprarenals, average weight.	Probable error.
Yrs.		*g.*	*g.*		*g.*	*g.*
Stillborn	5	7.00	±0.47	8	12.38	±0.76
Newborn	21	8.33	±0.31	9	9.22	±0.55
Under 1	6	6.67	±0.67	3	7.33	
1–2	2	6.00		4	6.75	
2–3				4	6.00	
3–4	9	6.22	±0.49	3	6.00	
4–5	4	7.00		6	5.00	±0.28
5–6	5	8.60	±0.70	3	6.67	
6–7	4	11.00				
7–8	14	8.93	±0.70	3	8.00	
8–9	4	8.75		2	9.00	
9–10	8	10.25	±0.56	3	7.33	
10–11	5	9.80	±0.64	3	10.33	
11–15	36	10.08	±0.36	10	12.10	±0.97

TABLE 6.—*Average normal weights of the right suprarenal in Filipino children.*

Age.	Male.			Female.		
	Cases.	Right suprarenal, average weight.	Probable error.	Cases.	Right suprarenal, average weight.	Probable error.
Yrs.		*g.*	*g.*		*g.*	*g.*
Stillborn	1	3.00		3	7.67	
Newborn	8	4.25	±0.10	3	4.00	
Under 1	3	4.00		1	4.00	
1–2	2	3.00		2	4.50	
2–3				3	3.00	
3–4	6	3.17	±0.33	2	2.00	
4–5	4	3.50		2	2.00	
5–6	5	4.20	±0.30	1	5.00	
6–7	4	5.00				
7–8	9	4.56	±0.37	2	4.00	
8–9	3	4.67		2	4.00	
9–10	4	5.50		2	5.00	
10–11	4	5.00		3	4.67	
11–15	22	5.36	±0.18	9	5.78	±0.59

TABLE 7.—*Average normal weights of the left suprarenal in Filipino children.*

Age.	Male.			Female.		
	Cases.	Left suprarenal, average weight.	Probable error.	Cases.	Left suprarenal, average weight.	Probable error.
Yrs.		*g.*	*g.*		*g.*	*g.*
Stillborn	1	3.00		3	8.33	
Newborn	8	4.00	±0.24	3	4.33	
Under 1	3	4.67		1	4.00	
1–2	2	3.00		2	5.00	
2–3				3	3.33	
3–4	6	3.50	±0.35	2	2.00	
4–5	4	3.50		2	3.50	
5–6	5	4.40	±0.45	1	5.00	
6–7	4	6.00				
7–8	9	5.00	±0.58	2	4.00	
8–9	3	5.67		2	5.00	
9–10	4	4.75		2	4.00	
10–11	4	5.00		3	5.67	
11–15	22	6.18	±0.33	9	6.78	±0.46

TABLE 8.—*Average normal weights of both kidneys in Filipino children.*

Age.	Male.			Female.		
	Cases.	Both kidneys, average weight.	Probable error.	Cases.	Both kidneys, average weight.	Probable error.
Yrs.		*g.*	*g.*	*g.*	*g.*	*g.*
Stillborn	6	23.33	±1.05	8	26.13	±1.40
Newborn	24	25.08	±1.04	10	28.10	±1.98
Under 1	7	53.14	±6.00	5	41.20	±4.97
1–2	5	60.80	±3.23	5	63.60	±3.12
2–3	2	78.00		4	68.00	
3–4	16	73.19	±2.24	3	79.00	
4–5	6	79.50	±3.76	7	88.29	±2.98
5–6	10	104.40	±3.51	8	93.75	±3.03
6–7	12	99.33	±4.34	3	86.00	
7–8	21	110.90	±3.30	6	89.67	±4.32
8–9	9	133.33	±5.74	3	127.67	
9–10	13	143.62	±9.51	4	124.50	
10–11	4	151.50		2	157.00	
11–15	66	167.58	±3.40	15	173.73	±6.18

TABLE 9.—*Average normal weights of the right kidney in Filipino children.*

Age.	Male.			Female.		
	Cases.	Right kidney, average weight.	Probable error.	Cases.	Right kidney, average weight.	Probable error.
Yrs.		*g.*	*g.*		*g.*	*g.*
Stillborn	1	12.00		3	14.33	
Newborn	8	13.13	±0.79	3	12.00	
Under 1	2	39.50		1	32.00	
1–2	4	29.25		5	30.40	±1.42
2–3	1	45.00		4	35.25	
3–4	14	35.21	±1.31	3	38.67	
4–5	5	38.00	±1.10	1	39.00	
5–6	7	49.29	±1.35	6	46.17	±1.79
6–7	10	49.80	±2.45	3	41.33	
7–8	12	55.17	±2.37	4	43.75	
8–9	7	67.00	±4.01	3	64.00	
9–10	9	67.78	±6.51	2	52.00	
10–11	2	70.00		2	77.50	
11–15	47	81.77	±2.05	13	83.23	±3.56

TABLE 10.—*Average normal weights of the left kidney in Filipino children.*

Age.	Male.			Female.		
	Cases.	Left kidney, average weight.	Probable error.	Cases.	Left kidney, average weight.	Probable error.
Yrs.		*g.*	*g.*		*g.*	*g.*
Stillborn	1	12.00		3	16.00	
Newborn	8	14.13	±0.72	3	14.00	
Under 1	2	42.50		1	35.00	
1–2	4	30.50		5	33.20	±1.74
2–3	1	50.00		4	32.75	
3–4	14	38.43	±1.12	3	40.33	
4–5	5	36.60	±1.87	1	40.00	
5–6	7	52.71	±2.72	6	47.67	±2.05
6–7	10	49.90	±2.75	3	44.67	
7–8	12	58.33	±2.93	4	46.25	
8–9	7	68.14	±3.91	3	63.33	
9–10	9	68.44	±6.42	2	65.00	
10–11	2	71.50		2	79.50	
11–15	47	85.66	±2.11	13	88.15	±3.51

SUMMARY AND CONCLUSIONS

From a study of the weights of fresh visceral organs from 338 necropsies of Filipino children dying of traumata, we have developed empirical formulæ and standard tables of the absolute average normal weights of organs in Filipino children.

It is interesting to note that during the child's first year of life the gain in weight of the principal organs studied is more rapid than at any other age, with the exception of the suprarenal glands which diminish in weight during the same period.

After the first year and before the age of 16, the yearly gain in weight is more or less constant and uniform, and may be represented by the slope of the linear equation derived for each organ by standard graphic methods.

The formula of the curve of the weights of each organ at different ages should, in our opinion, help in estimating the average weight of the organ at any age between 1 and 15 years.

We believe that our tables of the standard average weights of normal organs will also be of service in solving certain medicolegal problems, and in deciding whether or not pathological changes have affected the weights of these organs.

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ILLUSTRATION

TEXT FIGURE

FIG. 1. Graph of average normal weights of the heart in male Filipino children.

NORMAL WEIGHTS OF VISCERAL ORGANS IN ADULT FILIPINOS

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Similar to our previous study (1) on the normal weights of organs in Filipino children, we present in this paper the normal weights in adult Filipinos. Our summarized report shown in Table 1 represents the absolute weights of the principal visceral organs taken in a fresh state during post-mortem examinations.

Our data in this study includes 768 cases that died of violence or accidents, of which 620 were males and 148 females. The causes of death included drowning, falls, automobile accidents, extensive burns, shooting, stabbing, strangulations, lightning shocks, electrocutions, and the like. The deaths were almost always immediate and not preceded or accompanied by any known pathologic state.

For purposes of comparison we have included in Table 1 the normal weights of several organs in the Malay race as reported by Sitsen (2) in Java. As was to be expected Sitsen's findings compare favorably with ours. Castor (3) reported slightly smaller heart and kidneys and slightly larger liver and spleen for East Indians. He also reported slightly heavier organs for Burmans.

We have also included in Table 1 the normal weights of organs in Occidental races as given by Jackson. (4) It will be noted that, save for the pancreas, the absolute weights of organs of Occidentals are heavier than those of Filipinos. These findings are verified by the reports of Bean (5, 6) and of Huschke, Frerichs, Birch-Hirschfeld, Thoma, Bollinger, Kalmansohn, Posselt, Prenner, Monneret, as cited by Vierordt. (7)

The pancreas of Filipinos, however, is heavier than that of the Occidental races. This fact was observed by Sitsen in the Malays of Java. Based on Soekaton's (8) hypothesis, Sitsen attributes the large pancreas and salivary glands of Malays to a diet rich in carbohydrates.

TABLE 1.—*Normal weights of the principal visceral organs in adults.*

Organ.	Filipinos (De Leon, Garcia, De Jesus).			Malays (Sitsen). Mean, minimum, and maximum weights.	Occidentals (Jackson). Mean, minimum, and maximum weights.
	Cases.	Mean weight.	Minimum and maximum weights.		
Heart:		g.	g.	g.	g.
Male	620	278.11	230–330	252(220–270)	312
Female	148	237.18	170–310	214(180–250)	255
Spleen:					
Male	614	116.82	50–180	----	----
Female	147	91.84	40–140	----	----
Both	----	----	----	----	80–300
Liver:					
Male	494	1,211.04	900–1,500	1,290(980–1300)	----
Female	125	1,090.64	700–1,500	1,263(750–2180)	----
Both	----	----	----	----	1500(1000–2000)
Pancreas:					
Male	121	105.88	55–155	105	----
Female	39	86.23	50–120	99(80–150)	----
Both	----	----	----	----	80(60–100)
Both suprarenals:					
Male	287	15.96	12–20	----	----
Female	84	14.57	10–19	----	----
Both	----	----	----	10(5–20)	----
Right suprarenal:					
Male	187	8.35	6–11	----	4–18
Female	52	7.06	4–10	----	
Left suprarenal:					
Male	185	9.08	7–11	----	
Female	52	7.73	5–11	----	
Both kidneys:					
Male	556	240.13	160–320	210(170–250)	----
Female	146	218.86	110–320	202(180–250)	----
Right kidney:					
Male	397	117.57	70–170	----	115–150
Female	89	103.62	50–160	----	
Left kidney:					
Male	394	124.14	80–170	----	
Female	89	106.17	50–160	----	
Thymus:					
Male	69	23.20	12–34	----	----
Female	17	21.00	10–32	----	----
Both	----	----	----	10–20	12.85–25.28

It is also shown in Table 1 that the weights of organs in females are in all cases lighter than those in males. It may be noted further that the left kidney and suprarenal gland are slightly heavier than the corresponding ones of the right side. These observations are in accord with the reports of Jackson.

Tables 2 to 11 represent the average weights of the principal visceral organs of adult Filipinos classified according to age groups. They reveal a gain in weight for each organ as the individual increases in age up to a certain limit, when the organ appears to reach its maximum weight, after which it exhibits slight retrogression corresponding to advanced age.

TABLE 2.—*Average normal weights of the heart in adult Filipinos.*

Age.	Male.			Female.		
	Cases.	Heart, average weight.	Probable error.	Cases.	Heart, average weight.	Probable error.
Yrs.		*g.*	*g.*		*g.*	*g.*
16–20	110	255.45	±2.96	32	206.72	± 4.43
21–25	124	274.81	±3.91	32	221.81	± 4.14
26–30	101	275.75	±3.19	25	222.64	± 5.46
31–35	64	277.06	±4.24	8	231.88	±12.89
36–40	73	284.81	±4.02	9	244.44	±13.58
41–45	27	287.15	±5.88	7	256.00	± 7.70
46–50	39	291.00	±5.44	7	269.57	±14.10
51–55	26	302.00	± 7.33	2	295.00	
56–60	23	305.83	±6.74	6	299.33	±20.43
61–65	9	312.00	±7.10	2	308.50	
66–70	11	292.00	±7.96	4	287.50	
71–75	2	302.50		1	244.00	
76–80	5	298.80	±5.71	6	286.67	±23.55
81–85	1	297.00		1	257.00	
86–90	2	298.50		4	290.00	
91–over	3	292.00		2	277.50	

TABLE 3.—*Average normal weights of the spleen in adult Filipinos.*

Age.	Male.			Female.		
	Cases.	Spleen, average weight.	Probable error.	Cases.	Spleen, average weight.	Probable error.
Yrs.		*g.*	*g.*		*g.*	*g.*
16–20	104	124.36	±4.02	30	95.00	± 6.20
21–25	119	123.95	±3.37	30	103.37	± 5.23
26–30	98	126.61	±3.66	22	111.64	± 8.85
31–35	65	134.66	±5.36	9	79.78	± 2.98
36–40	67	115.31	±4.54	11	113.91	±14.04
41–45	30	101.23	±5.41	6	95.83	±10.46
46–50	40	112.48	± 6.50	9	81.11	± 6.06
51–55	25	84.68	±7.01	3	79.33	
56–60	21	91.33	± 6.16	6	80.33	± 7.25
61–65	11	70.82	±7.15	2	50.50	
66–70	17	94.94	±6.93	4	52.00	
71–75	3	90.67		2	56.00	
76–80	6	65.83	±8.91	6	53.00	± 5.19
81–85	2	71.00		1	46.00	
86–90	3	73.33		4	55.00	
91–over	3	54.67		2	46.50	

TABLE 4.—*Average normal weights of the liver in adult Filipinos.*

Age.	Male.			Female.		
	Cases.	Liver, average weight.	Probable error.	Cases.	Liver, average weight.	Probable error.
Yrs.		*g.*	*g.*		*g.*	*g.*
16–20	85	1,196.04	±19.39	30	1,078.93	±35.21
21–25	98	1,218.50	±17.22	24	1,094.79	±25.56
26–30	75	1,213.51	±18.75	17	1,114.88	±38.58
31–35	51	1,270.29	±24.55	6	1,158.83	±19.46
36–40	62	1,222.87	±19.91	9	1,277.89	±61.82
41–45	21	1,233.95	±38.35	5	1,176.40	±88.21
46–50	31	1,145.29	±23.52	6	1,227.00	±65.42
51–55	21	1,305.57	±56.06	3	1,219.67	----------
56–60	16	1,250.94	±43.03	6	929.17	±17.71
61–65	7	1,182.57	±47.71	1	972.00	----------
66–70	13	1,048.08	±50.37	4	1,028.75	----------
71–75	3	1,125.67	----------	2	758.50	----------
76–80	5	1,030.40	±33.88	6	978.67	±68.86
81–85	1	1,170.00	----------	1	786.00	----------
86–90	2	965.00	----------	3	956.33	----------
91–over	3	1,061.00	----------	2	835.50	----------

TABLE 5.—*Average normal weights of the pancreas in adult Filipinos.*

Age.	Male.			Female.		
	Cases.	Pancreas, average weight.	Probable error.	Cases.	Pancreas, average weight.	Probable error.
Yrs.		*g.*	*g.*		*g.*	*g.*
16–20	17	96.00	±3.81	7	91.43	±6.51
21–25	21	100.19	±4.57	7	86.14	±6.72
26–30	27	112.30	±3.10	5	93.80	±4.63
31–35	11	98.91	±4.48	2	91.00	----------
36–40	17	110.65	±4.57	1	105.00	----------
41–45	6	106.00	±7.82	3	112.33	----------
46–50	8	110.75	±5.56	1	85.00	----------
51–55	5	131.80	±7.41	2	92.00	----------
56–60	5	93.40	±9.70	3	73.00	----------
61–65	1	114.00	----------	1	81.00	----------
66–70	1	65.00	----------	2	62.00	----------
71–75	1	94.00	----------	--------	----------	----------
76–80	--------	----------	----------	2	57.50	----------
81–85	--------	----------	----------	1	61.00	----------
86–90	--------	----------	----------	2	79.00	----------
91–over	1	154.00	----------	--------	----------	----------

Table 6.—*Average normal weights of both suprarenals in adult Filipinos.*

Age.	Male.			Female.		
	Cases.	Both suprarenals, average weight.	Probable error.	Cases.	Both suprarenals, average weight.	Probable error.
Yrs.		*g.*	*g.*		*g.*	*g.*
16-20	49	15.18	±0.50	15	13.13	±0.65
21-25	53	16.42	±0.47	16	14.75	±1.06
26-30	49	15.06	±0.38	15	15.73	±0.82
31-35	35	16.31	±0.62	5	15.40	±1.37
36-40	28	16.43	±0.64	5	17.20	±1.51
41-45	16	16.75	±0.85	5	13.80	±0.40
46-50	22	16.50	±0.67	3	11.33	----------
51-55	10	16.20	±0.91	2	12.00	----------
56-60	9	15.78	±0.81	4	16.50	----------
61-65	5	15.60	±1.12	2	12.00	----------
66-70	6	15.33	±0.61	4	16.25	----------
71-75	1	19.00	----------	1	14.00	----------
76-80	1	18.00	----------	3	15.00	----------
81-85	--------	----------	----------	1	10.00	----------
86-90	2	14.50	----------	2	15.50	----------
91-over	--------	----------	----------	1	10.00	----------

Table 7.—*Average normal weights of the right suprarenal in adult Filipinos.*

Age.	Male.			Female.		
	Cases.	Right suprarenal, average weight.	Probable error.	Cases.	Right suprarenal, average weight.	Probable error.
Yrs.		*g.*	*g.*		*g.*	*g.*
16-20	30	8.47	±0.30	9	6.11	±0.47
21-25	36	8.50	±0.26	8	8.13	±0.70
26-30	23	8.09	±0.26	8	7.50	±0.34
31-35	22	8.55	±0.35	3	6.33	----------
36-40	23	8.13	±0.39	3	8.33	----------
41-45	12	8.42	±0.50	2	5.50	----------
46-50	15	7.80	±0.38	2	5.50	----------
51-55	7	8.86	±0.46	1	4.00	----------
56-60	9	8.44	±0.57	4	8.25	----------
61-65	3	8.67	----------	1	6.00	----------
66-70	4	7.75	----------	4	7.50	----------
71-75	--------	----------	----------	1	7.00	----------
76-80	1	8.00	----------	2	8.00	----------
81-85	--------	----------	----------	1	5.00	----------
86-90	1	7.00	----------	2	7.50	----------
91-over	--------	----------	----------	1	5.00	----------

TABLE 8.—*Average normal weights of the left suprarenal in adult Filipinos.*

Age.	Male.			Female.		
	Cases.	Left suprarenal, average weight.	Probable error.	Cases.	Left suprarenal, average weight.	Probable error.
Yrs.		*g.*	*g.*		*g.*	*g.*
16–20	30	9.20	±0.35	9	7.22	±0.49
21–25	36	9.42	±0.28	8	8.00	±0.61
26–30	22	8.64	±0.30	8	7.75	±0.54
31–35	22	9.68	±0.48	3	7.33	----------
36–40	23	8.39	±0.37	3	10.33	----------
41–45	12	9.00	±0.57	2	8.50	----------
46–50	15	8.87	±0.44	2	6.00	----------
51–55	7	9.57	±0.30	1	5.00	----------
56–60	8	8.50	±0.48	4	8.25	----------
61–65	3	9.33	----------	1	6.00	----------
66–70	4	8.25	----------	4	8.75	----------
71–75	--------	----------	----------	1	7.00	----------
76–80	1	10.00	----------	2	8.50	----------
81–85	--------	----------	----------	1	5.00	----------
86–90	1	7.00	----------	2	8.00	----------
91–over	--------	----------	----------	1	5.00	----------

TABLE 9.—*Average normal weights of both kidneys in adult Filipinos.*

Age.	Male.			Female.		
	Cases.	Both kidneys, average weight.	Probable error.	Cases.	Both kidneys, average weight.	Probable error.
Yrs.		*g.*	*g.*		*g.*	*g.*
16–20	97	234.09	± 3.35	31	214.26	± 5.91
21–25	106	235.51	± 2.57	31	232.87	± 5.77
26–30	89	240.17	± 3.12	21	233.62	± 8.49
31–35	58	245.93	± 4.07	9	214.56	± 8.70
36–40	66	242.44	± 4.09	7	278.43	±13.13
41–45	26	253.65	± 5.84	7	211.57	± 9.69
46–50	34	251.97	± 4.37	11	237.64	±17.56
51–55	23	258.30	± 6.23	2	182.00	----------
56–60	19	252.37	±11.18	6	191.67	± 6.68
61–65	10	235.90	± 8.04	3	165.33	----------
66–70	14	193.50	± 5.97	4	189.25	----------
71–75	3	309.67	----------	2	162.50	----------
76–80	5	214.40	±19.05	6	159.67	± 5.92
81–85	1	264.00	----------	1	118.00	----------
86–90	2	200.00	----------	4	206.00	----------
91–over	3	190.67	----------	--------	----------	----------

TABLE 10.—*Average normal weights of the right kidney in adult Filipinos.*

Age	Male.			Female.		
	Cases.	Right kidney, average weight.	Probable error.	Cases.	Right kidney, average weight.	Probable error.
Yrs.		*g.*	*g.*		*g.*	*g.*
16–20	60	115.10	±2.33	15	101.13	± 3.58
21–25	83	114.82	±1.67	15	111.27	± 4.68
26–30	52	117.88	±2.55	13	116.08	± 4.94
31–35	42	120.57	±2.53	3	97.67	
36–40	54	116.50	±2.44	4	123.50	
41–45	18	122.72	±3.78	4	104.50	
46–50	25	120.24	±3.53	8	119.63	±10.86
51–55	19	133.32	±6.94	2	91.00	
56–60	17	121.47	±5.88	6	95.33	± 3.68
61–65	6	125.00	±5.73	3	84.67	
66–70	10	86.30	±2.55	4	91.25	
71–75	2	167.50		2	82.50	
76–80	4	112.50		6	78.33	± 3.41
81–85	1	132.00		1	59.00	
86–90	2	90.00		3	99.33	
91–over	2	116.50				

TABLE 11.—*Average normal weights of the left kidney in adult Filipinos.*

Age.	Male.			Female.		
	Cases.	Left kidney, average weight.	Probable error.	Cases.	Left kidney, average weight.	Probable error.
Yrs.		*g.*	*g.*		*g.*	*g.*
16–20	60	120.62	±2.38	15	104.47	± 4.03
21–25	83	122.84	±1.55	15	113.07	± 4.30
26–30	53	124.21	±2.32	13	119.54	± 6.30
31–35	42	131.21	±2.69	3	103.00	
36–40	54	122.83	±2.32	4	130.50	
41–45	18	130.44	±3.66	4	117.75	
46–50	22	124.18	±4.78	8	113.50	±15.30
51–55	18	131.89	±3.76	2	91.00	
56–60	17	129.41	±6.85	6	96.33	± 3.61
61–65	6	127.00	±5.26	3	80.67	
66–70	10	94.20	±3.40	4	98.00	
71–75	2	167.50		2	80.00	
76–80	4	116.00		6	81.33	± 2.78
81–85	1	132.00		1	59.00	
86–90	2	110.00		3	107.00	
91–over	2	121.00				

Thus, the heart increases in weight until the age of 65 years or later, after which it decreases in weight. The spleen grows heavier up to the age of about 35 years, after which it diminishes progressively in weight, until at 90 years it is only about half of its weight at 35.

The liver becomes heavier up to the age of about 55 years, after which it diminishes in weight, until at 90 years it is only about three-fourths of its maximum weight. The kidneys increase slowly in weight up to 40 or 60 years, after which they gradually decrease in weight.

Similar findings have been reported by Bean,(9) and by Thoma, Muller, and Geist, cited by Vierordt.(10)

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NORMAL WEIGHTS OF VISCERAL ORGANS IN FILIPINOS IN RELATION TO LENGTH AND BODY WEIGHT

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TWO TEXT FIGURES

This study is based on 1,106 necropsies of accident cases including 855 males and 251 females, selected from more than 12,000 necropsies performed in the Department of Pathology and Bacteriology and the Department of Legal Medicine, University of the Philippines. We have recorded in Tables 1 and 2 the absolute average weights of normal visceral organs of male and female Filipinos classified in relation to crown-heel body length.

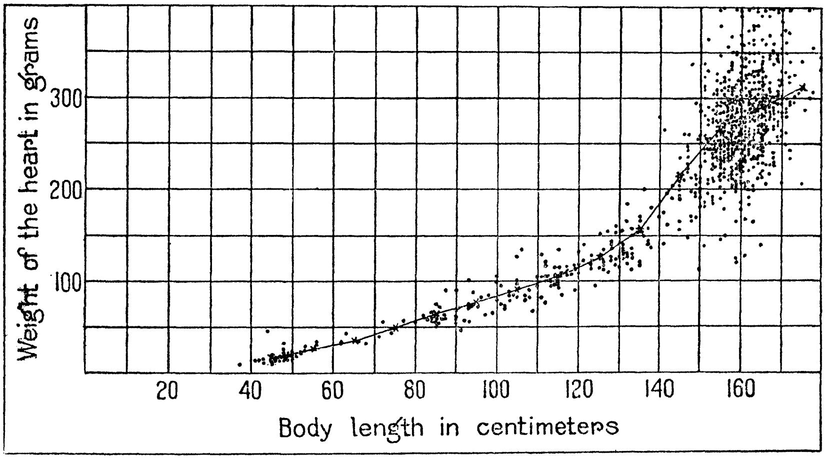

FIG. 1. The distribution of individual observations of the weight of the heart plotted against crown-heel body length.

Analysis of the tables shows that the weight of a visceral organ tends to increase with increasing body length, although the gain in weight is not equal for all length intervals. It is interesting to note from the study of these tables that for individuals of equal lengths there is generally no marked difference in the weights of organs between males and females.

In figure 1 the weight of the heart is plotted against the crown-heel body length. The dots represent individual observations. The crosses represent the averages of these observations at 10-cm intervals of body length. The curve shown by the solid line represents the point-to-point curve of the averages at 10-cm intervals from 45 cm to 175 cm, inclusive.

With the exception of the suprarenal glands, the other organs exhibit the same tendency of curve as the heart for both males and females. The suprarenal glands show decrease instead of increase in weight, among individuals (children) between 40 and 70 cm. Beyond 70 cm they present a type of curve similar to that shown by the other organs.

In Table 3 the proportion of organ weight to the entire body length is presented, expressed in grams per meter length.

Tables 4 and 5 show the weights of visceral organs of male and female Filipinos classified in relation to increasing body weight. From these tables it will be noted that for equal weights, the organs of females are slightly lighter than the corresponding organs of males. Furthermore, it will be observed that in general the weight of an organ increases with increasing body weight, although the gain in weight is not equal for all groups.

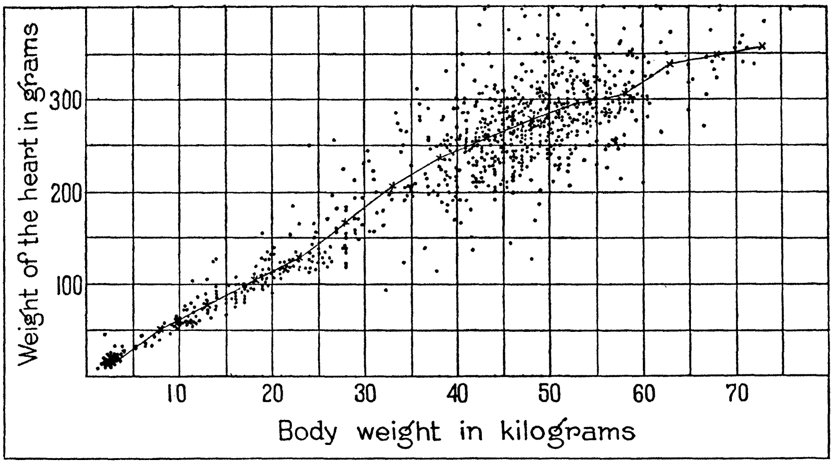

FIG. 2. The distribution of individual observations of the weight of the heart against body weight.

Fig. 2 shows the graphical representation of the weight of the heart plotted against body weight. The dots represent individual observations. The crosses represent the averages of these observations at 5-kg intervals of body weight. The solid line represents the point-to-point curve of the averages from 3.5 kg to 78 kg of body weight, inclusive.

TABLE 1.—*Weights of the principal visceral organs in relation to increasing body length (male).*

Body length.	Heart.		Spleen.		Liver.		Pancreas.		Suprarenals (both).		Kidneys (both).	
	Cases.	Average weight.	Cases.	Average weight.	Cases.	Average weight.	Cases.	Average weight.	Cases.	Average weight.	Cases.	Average weight.
cm.		*g.*		*g.*		*g.*		*g.*		*g.*		*g.*
45	31	17.87± 0.84	30	7.47±0.46	30	105.67± 4.01	8	2.75±0.23	24	7.88±0.28	28	25.14±0.71
55	6	26.33±1.57	6	14.50±1.59	6	153.00± 9.88	2	5.50	4	9.50	6	36.67±1.10
65	5	35.00±1.40	5	28.60±1.46	4	219.75	1	15.00	2	6.50	3	56.00
75	5	50.20±2.17	5	45.60±3.65	5	354.60±20.63	1	17.00	2	5.50	5	60.20±1.78
85	23	64.48±1.40	21	48.62±2.32	20	424.05±10.58	4	28.75	11	7.64±0.57	17	76.35±2.74
95	16	76.25±2.73	15	44.33±1.88	15	494.87±26.49	1	18.00	6	7.00± 0.65	14	92.29±2.87
105	21	89.76±2.41	21	50.10±2.19	22	600.82±27.53	5	36.00±2.95	10	8.40±0.70	20	104.70±6.01
115	36	106.44±3.55	34	65.41±3.88	32	661.41±14.94	12	51.17±3.21	19	9.37±0.44	29	116.66±5.52
125	30	127.73± 1.79	29	72.45±2.54	30	783.80±14.34	5	55.20±2.30	13	11.00±0.52	26	154.15±5.78
135	34	156.47±4.93	33	80.33±4.72	32	899.31±22.57	10	57.10±2.31	19	9.32±0.56	29	157.59±3.29
145	56	216.11±3.82	61	98.07±5.05	48	1,026.25±17.53	12	92.00±5.74	29	13.10±0.51	49	196.41±5.11
155	292	267.49±1.94	291	116.41±2.40	270	1,212.44± 9.89	56	103.16±2.45	147	15.86±0.29	270	231.46±1.72
165	265	292.07±2.37	262	123.67±2.74	238	1,256.14±11.53	57	108.60±2.39	124	15.69±0.27	243	249.34±2.12
175	35	312.60±5.84	34	153.18±7.66	30	1,444.20±38.36	3	104.67	7	18.14±0.74	33	287.06±7.72

TABLE 2.—*Weights of the principal visceral organs in relation to increasing body length (female).*

Body length.	Heart.		Spleen.		Liver.		Pancreas.		Suprarenals (both).		Kidneys (both).	
	Cases.	Average weight.	Cases.	Average weight.	Cases.	Average weight.	Cases.	Average weight.	Cases.	Average weight.	Cases.	Average weight.
cm.		*g.*		*g.*		*g.*		*g.*		*g.*		*g.*
45	14	18.43± 0.56	13	9.61±0.76	12	138.17± 6.14	5	3.60±0.56	14	10.50±0.64	14	27.29±1.62
55	6	21.33± 1.58	5	13.60±1.55	4	151.25			2	11.50	4	26.50
65	6	37.00± 2.67	5	27.60±1.43	5	206.20± 7.68	1	19.00	5	6.60±0.95	2	51.00
75	11	50.82± 1.22	11	34.82±1.90	9	337.89± 8.79	2	21.00	6	6.50±0.56	6	59.83±1.54
85	8	57.38± 1.87	8	40.00±2.10	8	417.88±30.94	2	20.50	3	7.33	6	78.00±2.45
95	17	75.76± 2.51	18	44.78±2.27	17	491.29±30.29	4	24.75	8	5.63±0.58	16	86.69±1.72
105	8	90.12± 2.82	8	47.50±1.98	8	525.00±24.78			4	7.75	7	96.00±3.68
115	8	90.00± 6.35	8	37.87±3.77	7	577.71±26.94	5	46.00±2.85	4	8.25	7	103.71±4.95
125	5	122.60± 5.33	5	80.20±9.86	5	702.60±43.61	1	50.00	2	11.00	5	144.20±7.42
135	17	182.76± 7.87	18	77.83±6.32	18	821.33±34.30	9	66.33±3.15	17	13.47±0.69	19	166.89±5.89
145	76	220.36± 3.60	69	85.96±3.10	74	1,053.31±15.47	12	81.67±3.45	38	12.72±0.43	69	206.57±3.73
155	69	260.14± 5.11	66	103.95±5.44	63	1,174.19±20.22	19	93.26±4.52	29	16.76±0.66	58	231.78±4.66
165	6	260.50±13.76	5	114.60±9.07	7	1,215.43±60.89			2	16.50	4	219.25

TABLE 3.—*Weights in grams of the principal visceral organs per meter body-length.*

Body length.	Male.						Female.					
	Heart.	Spleen.	Liver.	Pancreas.	Supra-renals (both).	Kidneys (both).	Heart.	Spleen.	Liver.	Pancreas.	Supra-renals (both).	Kidneys (both).
cm.												
45	39.7	16.6	234.8	6.1	17.5	55.9	41.0	21.4	307.0	8.0	23.3	60.6
55	47.9	26.4	278.2	10.0	17.3	66.7	38.8	24.7	275.0	----------	20.9	48.2
65	53.8	44.0	338.1	23.1	10.0	86.2	56.9	42.5	317.2	29.2	10.2	78.5
75	66.9	60.8	472.8	22.7	7.3	80.3	67.8	46.4	450.5	28.0	8.7	79.8
85	75.9	57.2	498.9	33.8	9.0	89.8	67.5	47.1	491.6	24.1	8.6	91.8
95	80.3	46.7	520.9	18.9	7.4	97.1	79.7	47.1	517.1	26.1	5.9	91.3
105	85.5	47.7	572.2	34.3	8.0	99.7	85.8	45.2	500.0	----------	7.4	91.4
115	92.6	56.9	575.1	44.5	8.1	101.4	78.3	32.9	502.4	40.0	7.2	90.2
125	102.2	58.0	627.0	44.2	8.8	123.3	98.1	64.2	562.1	40.0	8.8	115.4
135	115.9	59.5	666.2	42.3	6.9	116.7	135.4	57.7	608.4	49.1	10.0	123.6
145	149.0	67.6	707.8	63.4	9.0	135.5	163.2	59.3	726.4	56.3	8.8	142.5
155	172.6	75.1	782.2	66.6	10.2	149.3	167.8	67.1	757.5	60.2	10.8	149.5
165	177.0	75.0	761.3	65.8	9.5	151.1	157.9	69.5	736.6	----------	10.0	132.9
175	178.6	87.5	825.3	59.8	10.4	164.0	----------	----------	----------	----------	----------	----------

TABLE 4.—*Weights of the principal visceral organs in relation to increasing body weight (male).*

Body weight.	Heart.		Spleen.		Liver.		Pancreas.		Suprarenals (both).		Kidneys (both).	
	Cases.	Average weight.	Cases.	Average weight.	Cases.	Average weight.	Cases.	Average weight.	Cases.	Average weight.	Cases.	Average weight.
kg.		*g.*		*g.*		*g.*		*g.*		*g.*		*g.*
3.5	38	19.50±1.17	38	9.76± 0.91	37	115.51± 4.54	10	3.30±0.33	30	8.03±0.31	34	26.62± 0.86
8	18	50.83±3.31	18	39.11± 2.73	15	351.67±13.07	5	21.40±1.74	9	6.33±0.40	15	63.60± 2.41
13	40	76.65±1.90	38	50.39± 2.13	40	489.45±12.35	5	32.20±1.57	17	7.88±0.52	36	90.58± 3.09
18	49	104.59±2.72	46	59.74± 2.12	44	641.23±15.39	11	48.27±3.49	27	9.26±0.46	45	111.47± 3.00
23	39	128.97±2.76	39	68.92± 2.80	38	782.79±13.60	12	55.92±1.77	21	10.33±0.51	34	155.00± 3.86
28	34	165.88±4.12	28	79.96± 4.30	34	962.68±23.10	9	60.44±3.19	18	10.94±0.61	34	179.41± 3.76
33	31	206.94±5.56	29	83.69± 4.42	25	1,034.40±29.06	9	66.33±2.30	20	13.90±0.54	28	199.61± 6.33
38	66	236.03±3.33	63	98.13± 5.02	58	1,109.33±19.38	14	98.14±4.23	27	15.78±0.79	59	225.10± 4.93
43	132	257.82±2.43	136	108.35± 3.05	118	1,127.35±12.50	29	95.38±4.21	68	15.15±0.42	114	225.51± 2.82
48	165	279.19±2.68	157	115.35± 2.89	151	1,191.01±13.21	27	106.52±2.18	80	15.86±0.36	146	231.47± 2.19
53	133	298.92±2.68	129	135.95± 3.98	120	1,266.40±13.90	27	115.26±2.73	61	16.62±0.41	125	251.04± 2.95
58	70	305.11±3.58	70	138.06± 6.22	65	1,375.52±21.28	15	125.20±3.48	33	15.48±0.55	61	269.70± 4.60
63	17	338.47±8.92	17	161.23±15.13	15	1,528.13±37.56	3	114.00	4	17.75	16	281.19± 8.93
68	12	347.92±8.27	12	140.33±11.88	9	1,545.22±63.04	1	127.00	6	15.50±0.79	10	301.30± 9.78
73	6	357.83±4.48	6	124.83± 8.85	5	1,378.60±39.02	-------	---------------	2	18.00	5	279.00±11.62
78	1	413.00	1	87.00	1	1,495.00	1	170.00	1	18.00	1	272.00

TABLE 5.—*Weights of the principal visceral organs in relation to increasing body weight (female).*

Body weight.	Heart.		Spleen.		Liver.		Pancreas.		Suprarenals (both).		Kidneys (both).	
	Cases.	Average weight.	Cases.	Average weight.	Cases.	Average weight.	Cases.	Average weight.	Cases.	Average weight.	Cases.	Average weight.
kg.		*g.*		*g.*		*g.*		*g.*		*g.*		*g.*
3.5	22	19.73± 0.56	20	11.25± 0.83	18	148.39± 5.87	5	3.60±0.56	18	10.06±0.60	19	27.53± 1.33
8	23	52.74± 1.85	22	35.41± 1.32	21	369.33±23.23	5	20.60±1.22	13	6.69±0.42	12	70.33± 3.83
13	23	76.65± 3.35	25	47.28± 1.88	21	507.52±27.90	4	24.50	10	6.10±0.53	20	85.75± 1.49
18	11	95.91± 5.40	12	45.25± 3.16	11	537.91±17.75	4	43.25	4	7.25	10	105.00± 3.86
23	7	120.00± 8.75	6	62.17± 5.30	7	748.85±41.60	2	53.50	6	9.83±0.93	6	146.00± 6.31
28	13	195.08± 7.68	14	91.28± 7.81	12	875.67±61.48	6	60.00±4.47	8	13.00±0.98	12	167.00± 5.78
33	22	220.59± 8.26	24	67.62± 5.41	23	889.39±23.66	6	80.33±4.40	11	13.64±0.57	20	185.80± 6.01
38	50	225.84± 4.09	46	94.02± 4.32	47	1,081.62±17.31	9	81.67±1.75	27	13.26±0.51	47	215.64± 4.51
43	33	237.42± 6.78	32	98.41± 6.61	33	1,120.12±29.83	5	80.80±5.98	14	13.29±0.57	30	215.53± 6.04
48	21	239.90± 7.67	21	106.00± 7.56	20	1,160.25±26.08	10	96.00±5.71	10	19.90±1.15	20	236.25± 6.70
53	17	283.88±11.00	17	125.76±12.91	18	1,312.44±42.35	2	135.00	10	16.40±1.17	17	244.59±10.56
58	4	231.25	4	95.75	3	1,206.33					3	231.67
63	3	283.67	2	81.00	2	1,141.00			1	12.00	2	222.50
68	2	274.50	2	79.00	2	1,326.00			1	13.00	3	217.67
73											1	215.00
78	1	335.00	1	180.00								

TABLE 6.—*Percentage weights of the principal visceral organs in relation to the body weight.*

Body weight.	Male.						Female.					
	Heart.	Spleen.	Liver.	Pancreas.	Suprarenals (both).	Kidneys (both).	Heart.	Spleen.	Liver.	Pancreas.	Suprarenals (both).	Kidneys (both).
kg.												
3.5	0.56	0.28	3.30	0.09	0.229	0.76	0.56	0.32	4.24	0.10	0.287	0.79
8	0.64	0.49	4.40	0.27	0.079	0.79	0.66	0.44	4.62	0.26	0.084	0.88
13	0.59	0.39	3.76	0.25	0.061	0.70	0.59	0.36	3.90	0.19	0.047	0.66
18	0.58	0.33	3.56	0.27	0.051	0.62	0.53	0.25	2.99	0.24	0.040	0.58
23	0.56	0.30	3.40	0.24	0.045	0.67	0.52	0.27	3.26	0.23	0.043	0.63
28	0.59	0.29	3.44	0.22	0.039	0.64	0.70	0.33	3.13	0.21	0.046	0.60
33	0.63	0.25	3.13	0.20	0.042	0.60	0.67	0.20	2.70	0.24	0.041	0.56
38	0.62	0.26	2.92	0.26	0.042	0.59	0.59	0.25	2.85	0.21	0.035	0.57
43	0.60	0.25	2.62	0.22	0.035	0.52	0.55	0.23	2.60	0.19	0.031	0.50
48	0.58	0.24	2.48	0.22	0.033	0.48	0.50	0.22	2.42	0.20	0.041	0.49
53	0.56	0.26	2.39	0.22	0.031	0.47	0.54	0.24	2.48	0.25	0.031	0.46
58	0.53	0.24	2.37	0.22	0.027	0.47	0.40	0.17	2.08	----------	----------	0.40
63	0.54	0.26	2.43	0.18	0.028	0.45	0.45	0.13	1.81	----------	0.019	0.35
68	0.51	0.21	2.27	0.19	0.023	0.44	0.40	0.12	1.95	----------	0.019	0.32
73	0.49	0.17	1.89	----------	0.025	0.38	----------	----------	----------	----------	----------	0.29
78	0.53	0.11	1.92	0.22	0.023	0.35	0.43	0.23	----------	----------	----------	----------
Mean	0.58	0.27	2.82	0.22	0.051	0.55	0.58	0.28	3.10	0.21	0.076	0.58

The other organs exhibit the same tendency of curve for both males and females. An exception is found in the suprarenal glands, which recorded a reduction in weight for individuals with body weights between 2 and 10 kg, but beyond 10 kg the suprarenals follow the type of curve shown by the other organs.

Table 6 gives the proportion of organ weight to the weight of the entire body, expressed in percentage of the total body weight.

ILLUSTRATIONS

TEXT FIGURES

FIG. 1. The distribution of individual observations of the weight of the heart plotted against crown-heel body length.
2. The distribution of individual observations of the weight of the heart against body weight.

NEW OR LITTLE-KNOWN TIPULIDÆ FROM EASTERN ASIA (DIPTERA), XV[1]

By CHARLES P. ALEXANDER
Of Amherst, Massachusetts

TWO PLATES

The very interesting Tipulidæ discussed herein have been derived from a variety of sources. The unusually valuable collections from eastern Siberia, belonging to the zoölogical museum of the Russian Academy of Sciences, Leningrad, were included in rich series of these flies submitted to me for determination by Drs. Theodore Pleske and A. von Stackelberg, to whom I express my sincere thanks and appreciation for the opportunity of extending our knowledge of the Tipulidæ to the northward in eastern Asia. All types resulting from these materials are in the zoölogical museum of the Russian Academy of Sciences. The material from China is chiefly from the rich Graham collections in the United States National Museum, with other species in my own collection, collected by Messrs. Franck and Kellogg. The Japanese Tipulidæ were collected by Messrs. Esaki, Kariya, and Nakamura, the Esaki material being returned to Doctor Esaki for preservation in the entomological collection of Fukuoka Imperial University, the other specimens in my own collection through the continued kindly interest of the collectors.

TIPULINÆ

TIPULA (ACUTIPULA) BIPENICILLATA Alexander. Plate 2, fig. 25.

Tipula bipenicillata ALEXANDER, Philip. Journ. Sci. 24 (1924) 603–604.

The types were from Saghalien Island, collected by Esaki. Two additional males were taken at Ozenuma, Fukushima, Honshiu, Japan, July 28 and 29, 1931, by Nakamura, greatly extending the range of the fly.

The peculiar conformation of the inner dististyle (Plate 2, fig. 25, *id*) of the male hypopygium renders the fly easily recognizable. The rostral portion of the style is blackened and provided with small setæ; in the notch between this projection and the apical lobe extends a long slender pale rod. The outer dististyle (Plate 2, fig. 25, *od*) is broad, dilated at midlength, with sparse setæ that are chiefly marginal in distribution, as is common in the subgenus. Eighth sternite across caudal portion nearly straight or only slightly emarginate, with two widely separated groups or pencils of setæ.

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[1] Contribution from the entomological laboratory, Massachusetts State College.

TIPULA (ACUTIPULA) DESIDIOSA sp. nov. Plate 2, fig. 26.

General coloration of mesonotum gray, the præscutum with an intermediate pair of more grayish brown stripes; pleura light yellow, the anepisternum and ventral sternopleurite light gray; legs black, only the femoral bases narrowly brightened; wings grayish, almost immaculate, the usual dark spot in cell Cu very faintly indicated; bases of outer radial cells darkened; a conspicuous obliterative streak before cord; median lobe of ninth tergite of male hypopygium weakly notched at apex, set with abundant black spines.

Male.—Length, about 16 millimeters; wing, 17.5.

Frontal prolongation of head dark dorsally, somewhat brighter laterally; nasus elongate; palpi with basal segment dark brown, the succeeding segments much paler, the distal portion of last segment broadly dark brown. Antennæ with scape and pedicel light yellow; flagellum black, the basal portion of the first segment paler; verticils elongate. Head gray, with extremely vague indications of a darker median vitta.

Pronotum ocher-yellow. Mesonotal præscutum light gray, with an intermediate pair of more grayish brown stripes, in addition to paler brown lateral stripes; scutum light gray, the lateral portions of the lobes marked with grayish brown, the areas of the two lobes thus being unusually widely separated. Pleura light yellow, the anepisternum and ventral sternopleurite light gray; dorsopleural region buffy yellow. Halteres with stem dark brown, the base narrowly light yellow, the knob paler apically. Legs with the fore coxæ gray pruinose, yellow apically; remaining coxæ light yellow; trochanters yellow; legs black, only the very narrow femoral bases obscure yellow, broadest on the forelegs where about the basal fifth is brightened, on the hind legs the bright color almost obsolete. Wings with a grayish tinge, the stigma brown; a conspicuous whitish obliterative streak before cord, extending from before stigma into the base of cell M_3; bases of radial cells beyond cord, together with outer portion of cell M, a little infumed; a vague indication of a brownish cloud before midlength of cell Cu; veins brown. Venation: Rs a trifle longer than m-cu; M_{3+4} and basal section of M_3 subequal.

Basal abdominal tergites yellow, narrowly and interruptedly trivittate with dark brown, the lateral margins of the segments broadly buffy, on fifth and succeeding segments, the color passing into dark brownish gray; hypopygium dark; basal sternites yellow, the remainder dark. Male hypopygium with the median lobe of tergite, *9t*, long and slender, very weakly notched at apex, set with abundant black spicules. Outer dististyle, *od*, narrow at base, strongly curved and expanded outwardly, the surface with microscopic pale setæ only. Inner dististyle, *id*, with two beaklike portions, the outer ending in a triangular point and provided with numerous strong setæ; apex of style broadly and obtusely rounded, with a dense group of long setæ. Eighth sternite slightly produced and compressed medially.

Habitat.—China-Tibet border.

Holotype, male, Yin-Kuan-Tsai, altitude 13,000 to 15,000 feet, July 25, 1930 (*Graham*).

Tipula (*Acutipula*) *desidiosa* is clearly different from the other regional species of the subgenus. At first sight the species appears to fall in the group of clear-winged species allied to *munda*, but there is a distinct though very faint wing pattern, including the characteristic dark cloud in cell Cu. The nearest ally appears to be *T.* (*A.*) *kuzuensis* Alexander (Japan), which is distinct in the details of the male hypopygium, especially of the dististyles, the outer bearing a brush of long coarse setæ on margin near base.

TIPULA (ACUTIPULA) ONCERODES sp. nov. Plate 1, fig. 1; Plate 2, fig. 27.

Size large (wing over 25 millimeters); general coloration of mesonotal præscutum obscure yellow, with four brown stripes; antennal flagellum bicolorous; thoracic pleura yellow; wings tinged with brown, with a conspicuous whitish obliterative streak before cord; no dark spot in cell Cu; abdominal tergites obscure yellow, with a conspicuous sublateral brown stripe, the outer segments uniformly blackened; median lobe of tergite of male hypopygium simple.

Male.—Length, 25 to 27 millimeters; wing, 26 to 28; hind leg (type), femur, 20; tibia, 24.5; basitarsus, 32.

Frontal prolongation of head dark brown, narrowly reddish brown sublaterally above; nasus elongate; palpi brownish black. Antennæ relatively short, only a little longer than the palpi; scape obscure brownish yellow, weakly pruinose above; pedicel obscure yellow; flagellum bicolorous, the basal enlargements brownish black, the remainder brownish yellow; verticils elongate. Head dark grayish brown; anterior vertex relatively narrow, about twice the diameter of scape.

Posterior pronotum dark brown. Mesonotal præscutum obscure yellow, with four dark brown stripes, the intermediate pair widely separated on more than the anterior half, converging behind, confluent at suture; posterior sclerites of mesonotum chiefly dark brown; dorsal pleurotergite restrictedly darkened, the remainder light yellow. Pleura entirely light yellow. Halteres dark brown, the extreme base of stem yellowish, the apex of knob whitish. Legs with the coxæ and trochanters light yellow; femora brownish yellow, the tips narrowly blackened, the amount nearly equal on all legs, being a trifle less on posterior femora; tibiæ and tarsi brownish black. Wings (Plate 1, fig. 1) tinged with brownish, especially in the outer radial field; stigma and costal region darker brown than the ground; a conspicuous whitish obliterative streak before cord, crossing cell 1st M_2 into base of M_3; vein Cu at junction of m-cu vaguely suffused with brown; no dark spot in cell Cu; veins brown. Venation: Rs and m-cu subequal, the latter a short distance before the fork of M_{3+4}; vein R_{4+5} deflected caudad on outer portion, ending just behind the wing tip; basal section of M_{3+4} subequal to or shorter than the basal section of M_3.

Abdominal tergites obscure yellow, with a conspicuous sublateral brown stripe that is very narrowly broken by pale at caudal margins of segments; on fifth and succeeding tergites, the segments almost uniformly blackened; caudal margins of tergites very narrowly, lateral margins a little more broadly pale; sternites yellow, the outer segments dark brown; outer dististyle pale yellow. Male hypopygium with the median lobe of tergite broad-based, narrowed to the simple apex, which is set with abundant small black spicules. Outer dististyle (Plate 2, fig. 27, *od*) relatively narrow, a little dilated at midlength, the apex truncated. Inner dististyle, *id*, with a small dark-colored fingerlike lobe on outer margin at near two-thirds the length. Eighth sternite with a small U-shaped median incision that is bordered by weak setæ that are not arranged in brushes or pencils.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude, 3,500 feet, August 16, 1931 (*Franck*). Paratopotypes, males, August 14 to 16, 1931.

Tipula (*Acutipula*) *oncerodes* is allied to species such as *T.* (*A.*) *bipenicillata* Alexander, *T.* (*A.*) *biramosa* Alexander, and

T. (*A.*) *tokionis* Alexander, having the median lobe of the ninth tergite of the male hypopygium simple, and with the wings nearly immaculate, lacking any dark spot in cell Cu. The species is readily told from all such allied forms by its large size and structure of the male hypopygium, especially of the inner dististyle and the armature of the eighth sternite.

TIPULA (ACUTIPULA) LATIFASCIATA sp. nov. Plate 1, fig. 2.

Allied to *atuntzuensis;* general coloration olive-gray, the præscutum with four brown stripes; antennal flagellum almost uniformly blackish, scape and pedicel yellow; femora yellow, the tips narrowly and abruptly black; wings with the ground color brownish yellow, the radial cells beyond cord darker; dark spot in cell Cu conspicuous, preceded and followed by light yellow areas; a similar yellow spot at two-thirds the length of cell M; obliterative area before cord very wide, sending a narrower line across the bases of the outer medial cells; abdominal tergites chiefly pale brown, narrowly trivittate with darker; outer segments more uniformly darkened.

Female.—Length, 20 to 24 millimeters; wing, 18 to 20.

Frontal prolongation of head yellow dorsally, infuscated laterally beneath; nasus and palpi brownish black. Antennæ with the scape and pedicel yellow; flagellum almost uniformly darkened, the basal enlargements black, the remainder dull brownish black; verticils elongate. Head olive-gray.

Pronotum olive-gray. Mesonotum olive-gray, the præscutum with four brown stripes, the intermediate pair not attaining the suture and, in cases, a little more intensely colored along their mesal edges; each scutal lobe with a single darkened area; scutellum without dark median vitta. Pleura olive-gray, the ventral sternopleurite and most of anepisternum darker gray. Halteres blackened. Legs with the coxæ gray; trochanters yellow; femora yellow, the tips narrowly but conspicuously black, the amount including the distal fifth (forelegs) to sixth (hind legs); tibiæ brownish yellow, the tips narrowly dark brown; basal two segments of tarsi chiefly pale, narrowly tipped with black, the remaining segments uniformly darkened. Wings (Plate 1, fig. 2) with a strong brownish yellow suffusion, the stigma and spot in cell Cu darker brown; region beyond the obliterative band, including bases of outer radial cells and the outer half of cell 1st M_2 somewhat more infumed; m-cu narrowly clouded with darker; areas in outer half of cell M and in cell Cu on either side of the dark spot clear yellow; an unusually broad obliterative streak before cord, extending into bases of cells M_3 and M_4, thence continued outwardly to include the subbasal portions of cells M_1, 2d M_2, and a small contiguous spot in outer half of cell R_5; veins yellow, abruptly dark brown in the darkened area beyond the obliterative band, including vein M_{1+2} beyond the basal section, bases of M_1 and M_2, m, and the narrow adjoining portions of vein M_3; m-cu slightly less darkened. Venation: Rs a little exceeding m-cu; m a little shorter than the petiole of cell M_1.

Abdominal tergites chiefly pale brown, the basal segments more brightened, brownish yellow; a narrow blackened median vitta along tergites, together with somewhat broader sublateral stripes; lateral margins narrowly pale; basal sternites chiefly yellow, the outer segments passing into darker. Cerci long and slender.

Habitat.—China-Tibet border.

Holotype, female, Yu-Long-Gong, altitude 14,000 feet, August 14, 1930 (*Graham*). Paratypes, 1 female, Tatsienlu, altitude 8,000 to 9,000 feet, August 16, 1930; 1 female, near Yien Long Shien, altitude 13,000 to 15,000 feet, August 3 to 6, 1930.

The nearest ally of the present fly is *Tipula* (*Acutipula*) *atuntzuensis* Edwards (Yunnan), which differs conspicuously in the coloration of the legs, the femora being extensively and gradually infuscated on outer portions, not narrowly and abruptly blackened. The dark spot in cell Cu is broader in *atuntzuensis* while the pale obliterative band is narrower.

TIPULA (INDOTIPULA) SUBYAMATA sp. nov. Plate 2, figs. 28 and 29.

Male.—Length, 13 to 14 millimeters; wing, 15.5 to 17.5.

Female.—Length, about 21 millimeters; wing, 19.

Generally similar and closely related to *yamata* Alexander (Japan), differing especially in the details of structure of the male hypopygium.

Male hypopygium with the lobes of the ninth tergite (Plate 2, fig. 28, 9*t*) much broader and heavily blackened throughout. Outer dististyle, *od*, narrow, the tip obtusely rounded, the outer margin with setæ that are relatively much shorter and more scattered than in *yamata*. Inner dististyle, *id*, narrow, the outer margin with eighteen modified flattened setæ. The details of the hypopygium of *yamata* (Plate 2, fig. 29, 9*t*, *od*, *id*) are shown for comparison. Here the modified setæ of the inner dististyle total twenty-four in number.

Habitat.—China (Szechwan).

Holotype, male, Chunking, altitude 1,000 to 2,000 feet, May 6 to 27, 1930 (*Graham*). Allotopotype, female. Paratopotype, male.

TIPULA AMYTIS sp. nov. Plate 1, fig. 3.

General coloration gray, the præscutum with well-defined intermediate brown stripes, the lateral stripes diffuse; an additional capillary median brown vitta on præscutum; antennal scape dark brown, pedicel light yellow; apices of knobs of halteres obscure yellow; femora yellow, the tips black; wings pale brown, the stigma and a confluent seam on anterior cord dark brown; conspicuous whitish areas on disk, including an incomplete fascia beyond cord and stigma; basal abdominal tergites yellow, with a broad sublateral black stripe; terminal segments black.

Female.—Length, about 22 millimeters; wing, 21.

Frontal prolongation of head relatively long, gray pruinose, especially above; nasus distinct; palpi black. Antennæ with scape dark brown, the pedicel abruptly light yellow; flagellum broken. Head light gray, the center of vertex slightly infumed.

Mesonotal præscutum gray, with four brown stripes, the intermediate pair widely divided by a line of the ground color that is further split on cephalic portion by a capillary brown vitta; lateral stripes much paler and very broad and diffuse, reaching the lateral border of sclerite; posterior sclerites of mesonotum gray, variegated with darker areas. Pleura gray, the anepisternum and ventral sternopleurite somewhat darker gray; dorsopleural region more buffy brown. Halteres yellow, the basal half of knob more infuscated. Legs with the coxæ grayish pruinose; trochanters brownish yellow; femora yellow, tipped with black; remainder of legs broken. Wings (Plate 1, fig. 3) with the ground color pale brown, the prearcular and costal regions more yellowish; disk variegated by conspicuous whitish areas; stigma and a broad confluent seam on anterior cord dark brown; a similar colored, elongate-oval area at origin of Rs; the whitish areas include the basal third of cell M, confluent with subbasal areas in cells Cu and 1st A; a large area at two-thirds the length of cell M; small markings before and beyond origin of Rs; a conspicuous, incomplete, white crossband beyond cord, extending from costa through cell 1st M_2; wing tip uniformly darkened; darkened areas adjoining vein Cu more intense and deeply colored; veins brown, the obliterative areas conspicuous. Venation: R_{1+2} entire; Rs long, approximately twice m-cu; m shorter than petiole of cell M_1; cell 1st M_2 narrowed outwardly.

Abdominal tergites one to five yellow, beyond the second becoming more obscure; a broad sublateral black stripe, bordered externally by a light gray margin; segments six to nine black, the lateral pale borders very narrow and finally becoming obsolete. Ovipositor with cerci straight, the margins smooth.

Habitat.—China-Tibet border.

Holotype, female, near Tang-Gu, altitude 14,000 feet, August 3 to 6, 1930 (*Graham*).

Tipula amytis is distinctly different from the other regional species known to me. The wing pattern suggests certain species of *Acutipula*, but the elongate Rs renders such a subgeneric assignment doubtful.

TIPULA VITIOSA sp. nov. Plate 1, fig. 4.

General coloration gray, the præscutum with four poorly indicated darker gray stripes, the cephalic end of the sclerite with four more brownish areas; nasus unusually broad and weakly notched at apex; antennæ with scape brown, pedicel obscure yellow, flagellum black; wings brown, conspicuously variegated by darker brown and white, the latter including a narrow but complete crossband beyond the cord; vein R_{1+2} persistent, diverging widely from R_3, not much exceeding R_2 alone; abdominal tergites yellow, trivittate with dark brown.

Female.—Length, about 20 millimeters; wing, 17.5.

Frontal prolongation of head light gray above, more infuscated on sides; nasus unusually broad, its apex weakly notched; palpi dark brown. Antennæ with scape brown, pedicel obscure yellow, flagellum black; longest verticils exceeding the segments and unilaterally arranged. Head light gray, the vertex with a capillary brown line.

Mesonotal præscutum light gray, with four poorly indicated, darker gray stripes, the cephalic ends of the intermediate stripes and similar humeral areas before the pseudosutural foveæ light brown, producing a series of four subequal spots on cephalic portion of sclerite; posterior sclerites of mesonotum gray, the centers of the scutal lobes brown, the scutellum and mediotergite more or less suffused with brown. Pleura gray, the dorsopleural membrane buffy. Halteres relatively long, pale yellow, the knobs dark brown. Legs with the coxæ gray; trochanters obscure yellow; femora brownish yellow to obscure yellow, the tips narrowly and weakly darkened; tibiæ light brown, the tips scarcely darkened; tarsi dark brown; tibial spur formula 1-?-2. Wings (Plate 1, fig. 4) with the ground color brown, conspicuously variegated by darker brown and white areas; the dark markings include the stigma and a confluent area on anterior cord, a spot at origin of Rs, a small post-arcular area, and seams along veins Cu and 2d A; the white areas include a narrow but complete white crossband beyond cord, large jagged areas in cells R and M, the outer one in cell M being V-shaped; origin of Rs entirely surrounded by white areas; cubital and anal cells variegated with white; outer half of cell R_5 with central portion white; cells C and Sc light yellow; veins dark brown. Squama naked; macrotrichia of veins very small and sparse, lacking on R_3. Venation: R_{1+2} entire, without trichia, diverging widely from R_3 and only a little longer than R_2 alone; m and petiole of cell M_1 subequal; m-cu at fork of M_{3+4}.

Abdomen with basal tergite infumed, the succeeding tergites more yellowish to ocherous, with three narrow continuous brown stripes, the median one much narrower than the interspaces; sublateral stripes very broad, margined externally by very narrow pale borders; subterminal segments more uniformly darkened. Ovipositor with the basal shield blackened, polished; cerci horn-colored, long and straight, the margins smooth, the tips obtuse; hypovalvæ relatively short, blackened.

Habitat.—China-Tibet border.

Holotype, female, near Tang-Gu, altitude 14,000 feet, August 3 to 6, 1930 (*Graham*).

Tipula vitiosa is generally similar to *T. leucosema* Edward (Yunnan), especially in the wing pattern, but differs conspicuously in the coloration of the thorax and abdomen. The very broad, weakly notched nasus and the short, suberect R_{1+2} furnish conspicuous characters for the definition of the present fly.

TIPULA VIVAX sp. nov. Plate 1, fig. 5.

General coloration of thorax light gray, the three præscutal stripes concolorous, separated from one another by dark brown areas on the interspaces; scape and pedicel yellow, the flagellum weakly bicolorous; nasus very short and stumpy; halteres yellow, the knobs dark brown; femora yellow, the tips narrowly black; wings pale brown, the prearcular and costal regions abruptly light yellow; a conspicuous white pattern on disk, including a virtually complete crossband beyond cord; R_{1+2} entire; abdomen yellow, the subterminal segments darkened; basal segments narrowly trivittate with brown.

Female.—Length, about 15 millimeters; wing, 14.5.

Frontal prolongation of head brownish yellow; nasus very short and stumpy; palpi dark brown. Antennæ with scape and pedicel obscure yellow; flagellum very weakly bicolorous, the basal enlargement of each segment dark brown, the remainder paler brown. Head light gray.

Mesonotal præscutum chiefly light gray, this including the broad gray stripes, the interspaces variegated by linear brown dashes, there being two on either side of the median gray stripe; extreme cephalic end of præscutum with a short brown median dash; posterior sclerites of notum gray. Pleura light gray; dorsopleural membrane buffy. Halteres yellow, the knobs abruptly dark brown. Legs with the coxæ light gray; trochanters yellow; femora yellow, the tips narrowly and conspicuously black; tibiæ obscure yellow, the tips narrowly and gradually blackened; tarsi black; tibial spur formula 1–?–2, middle legs broken. Wings (Plate 1, fig. 5) with the ground color pale brown, the prearcular and costal regions light yellow; stigma darker brown than the ground; white areas as follows: A narrow but virtually complete crossband beyond cord, scarcely interrupted by a narrow dark seam along vein M_{1+2}; a broader pale band before cord, extending generally parallel to the first described band, extending across cells R_1, R, and M; large pale areas in bases of cells M and Cu, outer half of Cu, and in bases of anal cells; veins dark brown, flavous in the yellow costal region. Squama naked; numerous macrotrichia on veins beyond cord; distal three-fourths of R_{1+2} naked. Venation: R_{1+2} entire; r-m connecting with Rs at or before fork; cell 1st M_2 relatively small, pentagonal; m-cu connecting with M_4 some distance beyond base.

Abdomen chiefly yellow, the outer segments a little more suffused with darker; very narrow, brown, median and sublateral stripes on tergites, the extreme lateral margins more buffy white; on sternites the three brown stripes are broader, especially the median one. Genital segment and ovipositor yellow; cerci long and slender, nearly straight, with smooth margins.

Habitat.—China-Tibet border.

Holotype, female, Zya-Ha Pass, altitude 14,000 to 17,000 feet, July 25 to 27, 1930 (*Graham*).

The only described regional species that agrees at all closely with the present fly in its small size, persistent R_{1+2}, and in having the wing pattern somewhat similar, is *Tipula pedicellaris* Alexander, which differs in the black scape, distinct præscutal pattern, extensively blackened femora, and incomplete pale crossband beyond cord.

LIMONIINÆ

HEXATOMINI

EPIPHRAGMA OCELLARIS GRACILISTYLUS subsp. nov.

Quite as in typical *ocellaris* (Linnæus), differing in slight characters of the male hypopygium. Outer dististyle slenderer and nearly straight, only the extreme tip decurved. Lobes of tergite obtuse at tips, separated by a U-shaped notch.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Tigrowaja, Suchan district, June 16, 1927 (*Stackelberg*).

PSEUDOLIMNOPHILA BRUNNEINOTA sp. nov. Plate 1, fig. 6; Plate 2, fig. 30.

General coloration of mesonotum light reddish brown, without markings; antennæ brownish black throughout, flagellar segments long-cylindrical; halteres dusky; legs chiefly brownish black to black; wings strongly tinged with light brown or yellowish brown, the stigma small, long-oval, darker brown; R_2 about one-half R_{2+3}; m-cu about one-third its length beyond fork of M; abdominal tergites dark brown, the subterminal segments brownish black.

Male.—Length, about 5 to 5.5 millimeters; wing, 5.8 to 6.2.

Rostrum and palpi black. Antennæ brownish black throughout; flagellar segments long-cylindrical, the longest verticils about twice the segments; terminal segment a little longer than the penultimate. Head dark brownish gray.

Pronotum dark brown. Mesonotum light reddish brown, without markings; pleura more yellowish. Halteres dusky. Legs with the coxæ and trochanters testaceous-yellow; remainder of legs brownish black to black, only the femoral bases restrictedly obscure yellow. Wings (Plate 1, fig. 6) with a strong light brown or yellowish brown tinge, the costal region clearer yellow; stigma long-oval, darker brown; veins brown. Costal fringe relatively long; macrotrichia of veins long and abundant, including close series on veins beyond cord. Venation; Sc_1 ending just beyond fork of Rs, Sc_2 near its tip; R_2 about one-half R_{2+3}; R_{2+3+4} only gently arcuated; cell M_1 exceeding its petiole; m-cu about one-third its own length beyond fork of M; anterior arculus preserved.

Abdominal tergites dark brown, the sternite paler; subterminal segments brownish black; hypopygium dark. Male hypopygium (Plate 2, fig. 30).

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 7,000 feet, July 27, 1931 (*Franck*). Paratopotype, male, July 17, 1931.

The nearest allies of the present fly are *Pseudolimnophila chikurina* Alexander, of Formosa, which differs in the brownish gray coloration of the thoracic notum and pleura, and in the paler legs; and *P. fusca* (Brunetti), of the eastern Himalayas, which differs in the pale legs, brightened first flagellar segment, and presence of a narrow median præscutal stripe.

LIMNOPHILA (IDIOPTERA) USSURIANA sp. nov. Plate 1, fig. 7; Plate 2, fig. 31.

Allied to *trimaculata;* general coloration of thorax gray, the præscutum with indications of four darker brown stripes; antennæ of male of moderate length, the verticils slightly exceeding the segments; femora yellow, the tips narrowly blackened; wings pale yellow, with a heavy brown pattern; abdominal segments bicolorous, the bases pale, the apices brown.

Male.—Length, about 6 millimeters; wing, 7.5; antenna, about 2.4.

Female.—Length, about 7 millimeters; wing, 8; antenna, about 1.7.

Rostrum and palpi black. Antennæ with the scape dark brown, the pedicel and first flagellar segment yellow, remainder of flagellum black; verticils (male) slightly exceeding the segments; terminal segment about two-thirds the penultimate; antennæ (male) much shorter than in *trimaculata,* if bent backward extending to shortly beyond roots of halteres. Head gray.

Mesonotum dark with a heavy gray bloom to virtually obscure the ground; præscutum with vague indications of four darker stripes, these becoming more evident behind; pseudosutural foveæ conspicuous, black; tuberculate pits lacking. Pleura heavily gray pruinose. Halteres pale yellow, relatively long and slender. Legs with the coxæ yellow, the fore coxæ more darkened and pruinose at base; trochanters yellow; femora yellow, the tips narrowly and abruptly black, the amount subequal on all legs, including about the apical eighth or less; tibiæ obscure yellow, the tips narrowly darkened; tarsi chiefly dark brown. Wings (Plate 1, fig. 7) with the ground color pale yellow, the prearcular and costal regions a little brighter yellow; wing tip narrowly and vaguely darker; stigma brown; conspicuous brown clouds and seams, as follows: Origin of Rs, Sc_2, along cord and outer end of cell 1st M_2, fork of M_{1+2}, on supernumerary crossvein in cell M, and as marginal clouds at ends of veins R_3, M_4, and 2d A; veins brown. Venation: R_{2+3+4} about one-half longer than m-cu.

Abdominal tergites dark brown caudally and laterally, the remainder of disk obscure yellow; sternites pale yellow, the caudal margins of segments weakly darkened; segments eight and nine more uniformly dark brown, the basistyles of male hypopygium yellowish. In the female, the abdominal tergites are more uniformly darkened; valves of ovipositor long and slender. Male hypopygium (Plate 2, fig. 31) with the outer dististyle, *od,* relatively slender, the apex suddenly narrowed, the outer margin of distal half with abundant microscopic appressed spinulæ.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Tigrowaja, Suchan district, June 9, 1927 (*Stackelberg*). Allotopotype, female.

The only close ally of the present fly is *Limnophila* (*Idioptera*) *trimaculata* (Zetterstedt), a somewhat uncommon species of northern Europe, which differs in the more-elongate antennæ of the male, the more extensively blackened legs, and the less heavily patterned wings. The male hypopygium is very similar in the two species. The other European members of *Idioptera,* together with the three Nearctic species, all have the male hypopygia of entirely different structure. The relatively short antennæ of the male of the present fly approach the condition found in some species of the subgenus *Elæophila* Rondani (as the Nearctic *sabrina* Alexander), supporting Edwards's contention that the two groups are not sufficiently distinct for subgeneric separation.

LIMNOPHILA (DICRANOPHRAGMA) MELALEUCA sp. nov. Plate 1, fig. 8.

Size very small (wing, male, 4.5 millimeters); general coloration of mesonotum brownish gray, the præscutum with dark lines on interspaces; knobs of halteres conspicuously dark brown; femora brownish testaceous, with a pale brown subterminal ring, the tips narrowly but conspicuously white; wings (male) broadest opposite level of termination of vein 2d A; dark pattern confined to vicinity of veins; cells M to 2d A, inclusive, extensively washed with dusky.

Male.—Length, about 4 millimeters; wing, 4.5.

Rostrum and palpi black. Antennæ with the scape and pedicel black; flagellum obscure yellow, the outer segments darker. Head dark.

Mesonotal præscutum brownish gray, with a submedian, brown, longitudinal stripe, occupying the usual interspaces, with a spotlike area of the same color lying on outer margin of the usual lateral stripe, behind the pseudosutural foveæ; posterior sclerites of mesonotum darkened, sparsely pruinose. Pleura chiefly dark brown, sparsely pruinose. Halteres pale yellow, the knobs dark brown. Legs with the coxæ and trochanters brownish black; femora pale brownish testaceous, deepening to a pale brown subterminal ring, the subequal tips abruptly white; tibiæ and tarsi yellow. Wings (Plate 1, fig. 8) broadest at level of termination of vein 2d A; disk chiefly white, cells M, Cu, 1st A, and 2d A extensively washed with dusky, except at outer ends; a series of darker brown marginal spots, including six major areas along costa, the fourth and fifth confluent, lying above the fork of R_{2+3+4} and on R_2; cord, outer end of cell 1st M_2 and fork of M_{1+2} narrowly seamed with brown; veins dark in the clouded areas, pale yellow in the interspaces.

Abdomen, including hypopygium, dark brown.

Habitat.—Japan (Kyushu).

Holotype, male, Wakasugiyama, Chikuzen, August 7 to 9, 1931 (*Esaki et al.*).

Limnophila (*Dicranophragma*) *melaleuca* is readily told by the diagnostic features listed above, notably the small size, darkened knobs of halteres, white femoral tips, and expanded wings of male.

LIMNOPHILA (DICRANOPHRAGMA) MELALEUCA IGNAVA subsp. nov.

Male.—Length, about 4 to 5 millimeters; wing, 5.

Female.—Length, about 5.5 millimeters; wing, 6.2.

Characters as in the typical form, differing especially in the slightly larger size and slight details of coloration.

Wings with the darkening in cells Cu to 2d A less developed to nearly obsolete; dark marginal areas at ends of longitudinal veins larger, tending to become confluent with one another and with the submarginal darkenings at the supernumerary cross-vein in cell R_2 and the area at fork of M_{1+2}.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 7,000 feet, July 29, 1931 (*Franck*). Allotopotype, female, altitude 4,500 feet, August 12, 1931.

LIMNOPHILA (DICRANOPHRAGMA) LÆTITHORAX sp. nov. Plate 1, fig. 9; Plate 2, fig. 32.

General coloration dark brown or brownish black, the mesonotal præscutum and scutum more reddish brown, without markings; wings broad in male, narrower in female, the costal fringe relatively short in both sexes; wings with numerous dots in the cells, additional to the five major brown costal spots.

Male.—Length, 5.5 to 6 millimeters; wing, 6.5 to 8.

Female.—Length, 6.5 to 7 millimeters; wing, 6.5 to 7.

Rostrum and palpi black. Antennæ black, the first flagellar segment light yellow, the remainder of flagellum brownish black. Head brownish gray.

Mesonotal præscutum and scutum reddish brown pollinose, much brighter in color than the blackened, sparsely pruinose mediotergite and pleura; præscutum without darker markings with the exception of the black pseudosutural foveæ, and, in cases, a narrow outer margin to the outer lateral stripe. Halteres pale yellow. Legs with the coxæ blackened, sparsely pruinose; trochanters obscure yellow, blackened apically beneath; remainder of legs light yellow, the last tarsal segment darkened. Wings (Plate 1, fig. 9) broad in male, narrower in female; ground color pale cream-yellow, with a spotted and dotted brown pattern, the major areas including a series of five costal darkenings, one being postarcular, the second at origin of Rs, the third and fourth more or less confluent at the fork of Rs, leaving a pale spot between them in costal field; last major area at supernumerary crossvein; cord and outer end of cell 1st M_2 more narrowly seamed with brown; small circular brown dots in all cells, together with a series of slightly larger similar marginal spots at ends of all longitudinal veins; veins light yellow, darker in the infuscated areas. Costal fringe relatively short in both sexes, dark brown; in female, the setæ are somewhat shorter than the width of the costal cell. Venation: m-cu at near midlength of cell 1st M_2; cell M_1 shorter than its petiole.

Abdomen dark brown, the hypopygium more brownish yellow to yellow. Male hypopygium (Plate 2, fig. 32) with the outer dististyle, *od*, strongly bidentate at apex; inner dististyle, *id*, broad basally, narrowed outwardly, the apex with a series of four strong setæ in a single row.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 7,000 feet, July 27, 1931 (*Franck*). Allotopotype, female, pinned with type. Paratopotypes, 4 males and females, July 17 to 27, 1931 (*Franck*).

Limnophila (*Dicranophragma*) *lætithorax* is most nearly allied to the Formosan *L.* (*D.*) *taiwanensis* Alexander, which differs in the less-brightened mesonotal præscutum that is narrowly lined with brown on the interspaces, the more abundant dotted areas on wings, and the long, light yellow, costal fringe in the female, the trichia being approximately as long as the width of the costal cell.

LIMNOPHILA MARTYNOVI sp. nov. Plate 1, fig. 10.

General coloration light gray, the præscutum with two darker gray intermediate stripes; pseudosutural foveæ and tuberculate pits black, very conspicuous; femora yellow basally, the apices blackened, broadly so on forelegs; wings with the ground color yellow, with a heavy brown-spotted pattern; m and m-cu lacking; veins beyond cord almost without macrotrichia.

Female.—Length, about 10.5 millimeters; wing, 8.5.

Rostrum gray; palpi black. Antennæ 16-segmented, black, the scape heavily light gray pruinose; flagellar segments gradually decreasing in size outwardly, the terminal segment longer than the penultimate; verticils longer than the segments. Head light gray; eyes small, with fine ommatidia; anterior vertex wide; head prolonged behind eyes.

Pronotum large and conspicuous, gray. Mesonotal præscutum light gray, with two darker gray intermediate stripes; pseudosutural foveæ and tuberculate pits black, very conspicuous, the latter lying at cephalic portion of sclerite, diverging anteriorly; posterior sclerites of notum clear light gray, the scutal lobes vaguely marked with darker. Pleura, including the dorsal membrane, gray. Halteres pale, the knobs very weakly darkened. Legs with the coxæ light gray; trochanters brownish yellow; femora broadly blackened apically, the bases yellow, the black most extensive on forelegs where about the distal three-fourths is included, narrowest on the posterior legs where about the outer third or fourth is darkened; tibiæ yellowish brown, the tips narrowly darkened; tarsi black; legs with conspicuous setæ. Wings (Plate 1, fig. 10) with the ground pale yellow, with a heavy brown spotted and dotted pattern; costal cell chiefly dark brown by a series of extensive areas that are confluent on basal half of cell, cell Sc more extensively clear; large, paler brown areas at origin of Rs, along cord, and as postarcular darkenings in bases of cells R and M; marginal clouds at ends of all longitudinal veins; small brown dots in outer radial field and in cells M to 2d A, chiefly grouped along the veins; cells R_1, R, and M are chiefly clear of markings; veins brown. Macrotrichia of veins beyond cord very sparse, restricted to veins R_1 and R_{1+2}, and as a scattered series the entire length of R_5, more numerous and crowded on distal fifth; no trichia on anal veins and only one or two at outer end of Cu. Venation: R_{2+3+4} shorter than basal section of R_5; cell M_1 present; cell 1st M_2 open by atrophy of m; m-cu entirely lacking; anterior arculus preserved.

Abdomen dark gray, the tergites more suffused medially with brownish. Ovipositor with the cerci powerful, blackened on basal third, the horn yellow tips strongly upcurved.

Habitat.—Eastern Siberia (Ussuri).

Holotype, female, Maiche region, near Shkotowo, 132° 20′ east longitude, 43° 20′ north latitude, June 5, 1927 (*Martynov*); No. 205.

Limnophila martynovi is named in honor of the collector, Dr. A. Martynov, who has collected many interesting Tipulidæ in Ussuri. The single specimen available indicates a fly of unusual interest. The remarkable venation, wtih both m and m-cu lost by atrophy, is different from that in all related forms and certainly appears to represent a normal condition, since the two wings are quite alike. The exact systematic position of the fly is rendered in question because of the loss of m-cu and the sex of the specimen. The general features of venation are not unlike those found in *Dactylolabis* or *Limnophila,* sensu strictu, and if we disregard the two venational features above mentioned, the general appearance of the insect would be much as in either of these groups. All species of the two groups known to me, including virtually all of the described species, have numerous macrotrichia on the veins beyond the cord. I am inclined to believe that the present fly will be found to fall in or close to the typical subgenus *Limnophila.*

Genus HEXATOMA Latreille

Hexatoma LATREILLE, Gen. Crust. et Ins. 4 (1809) 210.

Subgenus ERIOCERA Macquart

Eriocera MACQUART, Dipt. exot. 1 1 (1838) 74.

Edwards[2] has reviewed critically the numerous names that have been proposed in the subgenus *Eriocera,* indicating those that deserve consideration as being valid. I certainly agree that *Penthoptera* should be placed in the strict synonymy of *Eriocera.* There remain three names that are here considered as representing valid subgenera under the oldest name, *Hexatoma.*

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[2] Ann. & Mag. Nat. Hist. IX 8 (1921) 67–99.

1. *Hexatoma* Latreille. Wings with cell R_3 present and with only two branches of M attaining the wing margin (M_{1+2} and M_4). Valves of ovipositor short and fleshy. As so restricted, the subgenus includes about eight valid species in Europe, one in Japan, and two in boreal America.

2. *Cladolipes* Loew. Characters as in *Hexatoma* but with cell R_3 of wings lost by fusion of veins R_3 and R_4 to margin. The group includes a single species, *simplex* Loew, of Greece.

3. *Eriocera* Macquart. All species have cell R_3 present. The number of free branches of media ranges from two to four, the low figure being found in a single species from the Seychelles Islands, which otherwise differs from *Hexatoma*, s. s., in the elongate valves of the ovipositor. The venation of the outer medial field is wonderfully plastic, and in many species these veins tend to become weak or even semiatrophied. An entirely comparable case is found in the eriopterine genus *Trentepohlia* Bigot. Ovipositor with elongate sclerotized valves, more rarely (*longicornis* group) with these short and fleshy. As so interpreted, *Eriocera* includes the vast bulk of the genus, with approximately two hundred species distributed in all temperate and tropical regions and subregions, with the exceptions of the Chilian and Maorian.

There seems to be no question but that the three groups here recognized are very closely allied and are maintained for convenience in handling the vast complex of species. The three subgenera may be separated as follows:

1. Wings with three or four branches of media attaining the margin; when only two such branches are found (*ferruginea* Edwards, Seychelles Islands); the ovipositor with sclerotized cerci............ *Eriocera* Macquart.
   Wings with but two branches of media attaining the margin; ovipositor with fleshy valves .... 2.
2. Wings with cell R_3 lacking... *Cladolipes* Loew.
   Wings with cell R_3 present... *Hexatoma* Latreille.

As a result of placing these groups in a single genus, a few names have become preoccupied and the species are renamed as follows:

HEXATOMA (ERIOCERA) BENGALENSIS nom. nov.

Hexatoma (*Eriocera*) *bicolor* MACQUART, Dipt. exot. 1 1 (1838) 66, non *Hexatoma* (*Hexatoma*) *bicolor* MEIGEN, Syst. Beschreib. 1 (1818) 209.

HEXATOMA (ERIOCERA) MADAGASCARIENSIS nom. nov.

Hexatoma (*Eriocera*) *obscura* BIGOT, Ann. Soc. Ent. France III 7 (1859) 123, non *Hexatoma* (*Hexatoma*) *obscura* MEIGEN, Syst. Bescreib. 1 (1818) 210.

HEXATOMA (ERIOCERA) WIEDEMANNI nom. nov.

Hexatoma (*Eriocera*) *nigra* WIEDEMANN, Aussereur. zweifl. Ins. 1 (1828) 27, non *Hexatoma* (*Hexatoma*) *nigra* LATREILLE, Gen. Crust. et Ins. 4 (1809) 260.

The species later described as *nigra* by Macquart (1838), and which is of unusual importance in the discussion in that it is the type of the subgenus, is herewith considered as being distinct from *nigra* Wiedemann. Enderlein (1912) described a species from Colombia as *Eriocera macquarti*, under the belief that the fly was conspecific with Macquart's *nigra*. This Colombian insect differs in certain important regards from Macquart's description and I am very doubtful that it will be found to be the same as Macquart's species. The presence of a red vertical tubercle in *macquarti* Enderlein but not in *nigra* Macquart renders the synonymy very doubtful.

HEXATOMA (ERIOCERA) LANIGERA sp. nov. Plate 1, fig. 11.

Belongs to the *spinosa* group; general coloration brownish gray, in male the præscutum with a conspicuous, dark brown, median stripe; antennæ (male) elongate, approximately three times the length of body; body (male) conspicuously hairy; legs black, the femoral bases narrowly but conspicuously bright yellow; wings brown, the prearcular region more yellowish.

Male.—Length, about 17 to 18 millimeters; wing, 20 by 4.8; antenna, about 50 to 55.

Female.—Length, about 25 millimeters; wing, 19; antenna, about 5.

Male.—Rostrum and palpi black. Antennæ black throughout, approximately three times the length of the body; flagellar segments with coglike spines, as in group. Head grayish brown, with a dense pale pubescence; vertical tubercle conspicuous.

Mesonotal præscutum brownish gray, clearer gray on humeral and lateral portions, with a conspicuous dark brown median line; posterior sclerites of notum more grayish; notum with conspicuous erect setæ. Pleura blackish, heavily pruinose with light gray, especially on the ventral portions. Halteres brown, the knobs brownish black. Legs with the coxæ gray pruinose; trochanters brownish black, sparsely pruinose; femora black, the bases broadly bright yellow, including about the basal third or fourth on the fore and middle legs, about the basal fifth on the posterior femora; remainder of legs black. Wings (Plate 1, fig. 11) relatively narrow, with a strong brown tinge, the costal region somewhat darker; prearcular region more yellowish; stigma barely indicated; a dark seam along vein Cu;

centers of basal cells from R to 2d A paler than the borders; veins brown. Macrotrichia of veins very sparse; costal fringe short and appressed; veins beyond cord without trichia, excepting a few scattered ones on distal section of vein R_5. Venation: R_{2+3} longer than R_{1+2}, the latter about three times R_2 alone; cell M_1 present but variable in size; m-cu at or close to midlength of cell 1st M_2.

Abdomen chiefly dark brown, the sternites pruinose; hypopygium light brown to yellowish brown; abdomen conspicuously hairy.

Female.—Generally similar to male except in the sexual features of short antennæ and short, inconspicuous pubescence of the body. Median dark stripe on præscutum lacking.

Habitat.—China-Tibet border.

Holotype, male, Yin-Kuan-Tsai, altitude 13,000 to 15,000 feet, July 25, 1930 (*Graham*). Allotopotype, female. Paratopotype, male.

Hexatoma (*Eriocera*) *lanigera* is closest to *H.* (*E.*) *stricklandi* (Edwards), of Japan, differing most evidently in the dark coloration of the wings and the distinct pattern of the legs, which in the present fly are black with only the femoral bases narrowly yellow.

HEXATOMA (ERIOCERA) TIBETANA sp. nov. Plate 1, fig. 12.

Belongs to the *spinosa* group; general coloration gray; vestiture of body short in both sexes; antennæ (male) of moderate length, subequal to the body; femora broadly yellow basally, the tips blackened, narrowly so on fore and middle legs, broadly on posterior femora; wings fulvous, stigma small, brown; cell M_1 present; abdominal tergites brownish black, the sternites and genital region of both sexes yellowish.

Male.—Length, 15 to 16 millimeters; wing, 18 by 4.8 to 20 by 5.1; antenna, 15 to 16.

Female.—Length, about 25 millimeters; wing, 21 by 6.

Male.—Rostrum dark brown; palpi black. Antennæ of moderate length, approximately as long as body, black throughout; flagellar segments with the usual armature of spines. Head brownish gray; vertical tubercle very large and protuberant.

Mesonotal præscutum yellowish gray, with three darker, more brownish stripes, in addition to a narrow, more blackish, median vitta; lateral stripes small and relatively indistinct; lateral border of sclerite narrowly blackish; posterior sclerites of mesonotum chiefly brownish gray; vestiture of notum reduced to small, dark-colored setæ. Pleura heavily light gray pruinose, with scattered elongate whitish setæ. Halteres dark brown. Legs with the coxæ light gray, with long pale setæ; trochanters yellow; femora chiefly bright yellow, the tips blackened, on fore and middle legs narrowly so, involving about the basal third or fourth, on posterior legs more extensively, including about the outer two-thirds; tibiæ brown; tarsi darker brown. Wings (Plate 1, fig. 12) with a strong fulvous tinge, the prearcular region and cell Sc brighter yellow; stigma small, brown; centers of most of cells with paler, more grayish centers; veins yellowish brown. Macrotrichia of veins very scanty, as is the case in almost all members of the group. Venation: Cell M_1 present.

Abdominal tergites brownish black, the extreme lateral margins pale; sternites yellow; hypopygium brownish yellow; abdomen with inconspicuous short white setæ.

Female.—Characters as in male, except in the sexual differences. Halteres with stem light brown, the knobs dark brown. Ovipositor with the elongate tergal shield fulvous; valves elongate, nearly straight.

Habitat.—China-Tibet border.

Holotype, male, near Tang-Gu, altitude 14,000 feet, August 3 to 6, 1930 (*Graham*). Allotopotype, female. Paratype, 1 male, Tatsienlu, altitude 8,000 to 9,000 feet, August 16, 1930.

Hexatoma (*Eriocera*) *tibetana* is readily told from the allied *H.* (*E.*) *lanigera* sp. nov. by the much shorter antennæ of the male and the short vestiture of the thoracic notum in the male.

HEXATOMA (ERIOCERA) MEDIOFILA sp. nov. Plate 1, fig. 13.

Belongs to the *spinosa* group; mesonotum yellowish gray, the præscutum with a median blackish vitta and blackened lateral margins; antennæ relatively short, subequal in length to the body; legs black, the femoral bases rather narrowly yellow; wings with a strong fulvous-brown tinge; stigma small, brown; cell M_1 lacking; abdominal tergites black, sternites obscure yellow.

Male.—Length, about 13.5 millimeters; wing, 16 by 4.1; antenna, 13.

Rostrum yellow, grayish pruinose; palpi elongate, black. Antennæ black throughout, subequal in length to body; flagellar segments with the usual spines and spinous setæ found in males of this group. Head brown; vertical tubercle large; setæ of head long, dark-colored.

Mesonotal præscutum yellowish gray, with a broad, median, pale brown stripe that is further split by a narrow blackish vitta; lateral stripes ill-defined, grayish; posterior interspaces more yellowish; lateral margins of sclerite narrowly blackish; posterior sclerites of mesonotum blackish, very sparsely pruinose, the scutellum more heavily so; vestiture of notum short, chiefly pale. Pleura blackish, light gray pruinose, with sparse pale elongate setæ. Halteres pale brown, the knobs dark brown. Legs with the coxæ pruinose, with sparse pale setæ; trochanters yellowish; femora yellow basally, the tips very broadly blackened, on forelegs including about the outer two-thirds, on middle legs one-third, on posterior legs slightly more than four-fifths; tibiæ and tarsi black. Wings (Plate 1, fig. 13) relatively narrow, with a strong fulvous-brown tinge; prearcular region and cell Sc clear light yellow; stigma small, brown; veins pale brown. Venation: Cell M_1 lacking.

Abdominal tergites black; sternites obscure yellow, variegated sublaterally by pale brown; hypopygium dark; vestiture of abdomen relatively long and pale.

Habitat.—China-Tibet border.

Holotype, male, Yu-Long-Si, altitude 15,600 feet, July 28, 1930 (*Graham*).

Despite the lack of cell M_1 of the wings, I am referring this insect without question to the *spinosa* group, where it is unique in this venational feature. It is most similar to *Hexatoma* (*Eriocera*) *tibetana* in the general appearance and relative length of the antennæ of the male and differs in the notable increase in the amount of black on femora.

HEXATOMA (ERIOCERA) STACKELBERGI sp. nov. Plate 1, fig. 14.

Belongs to the *verticalis* group; general coloration gray pruinose; antennæ (male) short; mesonotal præscutum with three brownish black stripes; knobs of halteres pale yellow; legs black, with about the basal half of femora yellow; wings whitish subhyaline, all veins bordered by brown; R_{1+2}, R_2, and R_{2+3} subequal; cell 1st M_2 elongate; abdomen stout, black, conspicuously clothed with black setæ; hypopygium large, black.

Male.—Length, about 8 to 9 millimeters; wing, 7.5 to 9.

Rostrum and palpi black. Antennæ (male) short, if bent backward not attaining the wing root, 7-segmented; black, the basal segment pruinose; flagellar segments gradually decreasing in length, the terminal segment about one-half the penultimate. Head gray pruinose, the broad vertical tubercle more whitish gray.

Mesonotal præscutum gray with three brownish black stripes; scutum gray, each lobe with two brownish black areas; posterior sclerites of notum light gray; setæ of notum short and inconspicuous. Pleura gray, the dorsopleural membrane dark. Halteres dusky at bases, the knobs and outer half of stem light yellow. Legs with the coxæ and trochanters black, the former pruinose; femora with slightly more than the basal half light yellow, the outer portion black; remainder of legs black. Wings (Plate 1, fig. 14) whitish subhyaline, all veins bordered by brown to give a streaked appearance. Macrotrichia of veins very sparse or lacking; costal fringe short but dense; veins beyond cord without trichia excepting a scattered series of relatively long ones the entire length of outer section of vein R_5, more crowded on distal third. Venation: R_{1+2}, R_2, and R_{2+3} all subequal; R_{2+3+4} about two-thirds R_3; cell 1st M_2 long, about equal to the longest vein beyond it, the latter elements not showing signs of atrophy; m-cu just beyond fork of M.

Abdomen stout, black, with abundant coarse erect setæ; hypopygium large, black, the narrow tergal plate polished black.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Tigrowaja, Suchan district, June 8, 1927 (*Stackelberg*). Paratopotypes, 2 males, June 9 to 11, 1927.

Hexatoma (*Eriocera*) *stackelbergi* is named in honor of the collector, Dr. A. von Stackelberg, whose extensive collections in Ussuri have vastly enriched our knowledge of this region. The species is quite different from all other regional members of the subgenus, being most nearly related to *H.* (*E.*) *nipponensis* (Alexander) and allies, differing in the brown borders to the veins, the nearly glabrous outer veins of wing, the stout abdomen with unusually large hypopygium, and other characters. The fly is likewise generally similar and not distantly allied to *H.* (*E.*) *austera* (Doane), of western North America.

HEXATOMA (ERIOCERA) GIFUENSIS sp. nov. Plate 1, figs. 15, 16; Plate 2, fig. 33.

Belongs to the *verticalis* group; general coloration black, probably pruinose in fresh specimens; antennæ (male) elongate, being approximately three times the body, the flagellar segments with numerous slender spines; tips of femora blackened; wings with a faint yellow tinge, the stigma dark brown; R_{2+3+4} about two-thirds to three-fourths the length of R_3 alone; m-cu a short distance beyond fork of M.

Male.—Length, about 12 millimeters; wing, 12; antenna, about 30.

Female.—Length, 13 to 14 millimeters; wing, 10.5 to 11.5; antenna, about 2.2.

Described from alcoholic specimens.

Rostrum brown; palpi black. Antennæ of male elongate, nearly three times the body; basal segment brownish yellow, flagellum black; flagellar segments with conspicuous erect spines; antennæ of female 10-segmented. Head dark brown, the genæ brighter; vertical tubercle of male unusually large and high, of female smaller but still conspicuous.

Mesonotum and pleura black, probably pruinose in fresh specimens, any bloom or stripes that may be present destroyed by immersion; interspaces (male) with a dense erect pale pubescence. Halteres pale, the knobs dark brown. Legs with the coxæ darkened basally, the tips brighter; trochanters of male brownish black, of female more yellowish; femora yellow, the tips narrowly blackened; tibiæ and basitarsi brownish yellow, the tips narrowly blackened; outer tarsal segments black; segments of legs with conspicuous setæ. Wings (Plate 1, fig. 15) with a faint yellow tinge, the costal region clearer yellow; stigma dark brown; cord and vein Cu narrowly seamed with brownish; veins brown, Sc more yellowish. Macrotrichia of veins beyond cord very scanty, occurring on distal section of R_5. Venation: R_{2+3+4} about two-thirds to three-fourths R_3 alone; R_{2+3} subequal to R_2; m-cu a short distance beyond fork of M, the distance not exceeding one-third the length of m-cu itself.

Abdomen black. Male hypopygium (Plate 2, fig. 33) with the apical spine of the outer dististyle, *od*, long and nearly straight; only a few, very weak denticles on ventral side at base of spine.

Habitat.—Japan (Honshiu).

Holotype, alcoholic male, Gifu, Mino, June 6, 1931 (*Kariya*). Allotopotype, alcoholic female. Paratopotypes, 2 broken alcoholic females.

Hexatoma (*Eriocera*) *gifuensis* differs from *H.* (*E.*) *moriokana* (Matsumura) in the dark coloration of the body, the brown wing veins, and the details of venation, notably the position of m-cu at or just beyond the fork of M. Edwards has contended that *moriokana* is a synonym of *verticalis* (Wiedemann), but if Matsumura's description and figure of *moriokana*[3] are approximately correct, this can hardly be the case. The present fly is certainly distinct from *verticalis*, the wing of which is shown for comparison (Plate 1, fig. 16), the obliquity of the cord being a conspicuous character. There are certain discordant features in Matsumura's account of his species. His figure shows the elongate antennæ of a male attached to the body of a female. The length of the antennæ of *moriokana* as given by Matsumura (78 millimeters) is obviously too great. The description calls for a length about four times that of the body and might be assumed to total approximately 38 to 40 millimeters.

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[3] Thousand Insects Japan, Additamenta 2 (1916) 470–471, pl. 25, fig. 11.

HEXATOMA (ERIOCERA) OMEIANA sp. nov. Plate 1, fig. 17.

Belongs to the *verticalis* group; general coloration gray, the præscutum with four shiny black stripes; antennæ (female) 11-segmented; knobs of halteres dark brown; femora yellow, the tips blackened, broadly so on the forelegs, more narrowly on posterior femora; wings with a faint brown tinge; stigma oval, darker brown; veins very insensibly seamed with darker; R_{2+3} very short to lacking; R_{2+3+4} subequal to distal section of R_3.

Female.—Length, about 11 to 12 millimeters; wing, 9 to 11.5; antenna, about 2.3 to 2.5.

Rostrum reddish brown; palpi black. Antennæ (female) 11-segmented, if bent backward ending before the wing root; flagellar segments gradually decreasing in length outwardly, the first segment subequal to the succeeding three segments combined; scape, pedicel, and extreme base of first flagellar segment yellowish on lower surface, the remainder of organ black. Head black, with a sparse gray bloom; vertical tubercle of moderate size, subnitidous.

Mesonotal præscutum gray, with four shiny black stripes, the intermediate pair ending before suture, more or less confluent at their cephalic ends; posterior sclerites of notum light gray pruinose, the scutellum more heavily so. Pleura, including the dorsopleural region, dark gray. Halteres pale, the knobs dark brown. Legs with the coxæ gray pruinose; trochanters with outer faces infuscated, the inner aspect yellow; femora yellow basally, the tips blackened, somewhat more broadly so on forelegs where approximately the basal half or more is darkened, narrowly on the posterior femora where the outer fifth or sixth is blackened; one paratype shows all femora with the tips only narrowly blackened; tibiæ light brown, the tips narrowly black; tarsi black. Wings (Plate 1, fig. 17) with a faint brown tinge; stigma oval, slightly darker brown; veins brown, very insensibly margined with dusky. Macrotrichia of veins relatively sparse, beyond cord with a dense series on distal section of vein R_5, and, in cases, with one or two trichia on either or both outer sections of M_{1+2}; costal fringe dense. Venation: R_{2+3} very short to lacking; R_{1+2} a little exceeding R_2; R_{2+3+4} elongate, subequal to or a trifle shorter than R_3; m-cu variable in position, from being placed at fork of M to a distance beyond this fork about equal to one-half the length of m.

Abdomen black, subnitidous. Ovipositor with the unusually long and slender cerci horn-colored, the basal shield blackened at base.

Habitat.—China (Szechwan).

Holotype, female, Mount Omei, altitude 4,000 feet, August 10, 1931 (*Franck*). Paratopotypes, 8 females, August 9 to 10, 1931.

By Edwards's key to the Old World species of *Eriocera*, the present fly runs out at couplet 22, agreeing most nearly with *Hexatoma* (*Eriocera*) *nigrina* (Riedel), of Formosa, which differs in the uniformly darkened wings and shorter vein R_{2+3+4}.

HEXATOMA (ERIOCERA) LUTEICOSTALIS sp. nov. Plate 1, fig. 18.

Belongs to the *longicornis* group; general coloration gray, the præscutum with three brown stripes, the median one divided by a capillary dark brown vitta; antennæ (male) a little more than three times the length of body; spines of flagellar segments unusually scanty; wings with a faint brownish yellow tinge, the prearcular and costal regions light yellow; R_{2+3} long, from one-third to more than one-half R_{2+3+4}; m-cu close to fork of M (male) or slightly beyond (female).

Male.—Length, about 10 millimeters; wing, 12.2; antenna, about 33.

Female.—Length, about 9 millimeters; wing, 11; antenna, about 2.

Rostrum and palpi brownish black, the latter small and slender. Antennæ (male) elongate, slightly exceeding three times the body; scape enlarged, dark brown; pedicel very small, yellowish brown; flagellum black, the base of first segment obscure yellow; spines of the flagellum very scanty, on the basal segment there are about five, restricted to the distal half of segment; segment two with about eighteen spines, of which only six or seven are large, the alternate ones being microscopic; third flagellar segment with about seven large spines from tuberculate bases, with two or three smaller spines and delicate setæ arranged between the members of each pair of tubercles; terminal segment with only small scattered spinulæ. In female, antennæ 9-segmented, gradually decreasing in length to near end, the terminal three segments small and nearly equal in size. Head brownish gray; vertical tubercle (male) very large, of female smaller but still conspicuous.

Mesonotal præscutum gray, with three slightly darker brown stripes, the median one divided by a capillary dark brown vitta; posterior sclerites of notum yellowish gray, the scutal lobes variegated by ill-delimited brown areas; notum of male with dense erect pale setæ, that of female with setæ somewhat shorter but still long and conspicuous. Pleura gray pruinose. Halteres pale, the knobs very weakly darkened. Legs with the coxæ dark-colored, pruinose; trochanters obscure yellow; femora brownish yellow, the tips rather narrowly blackened; tibiæ and tarsi brown, of forelegs considerably darker than the hind legs. Wings (Plate 1, fig. 18) with a faint brownish yellow tinge, the prearcular and costal regions clear light yellow; stigma relatively small, pale brown, distinct; scarcely indicated darker seams along cord and veins Cu and R_5; veins dark brown, pale yellow in the flavous areas. Veins with very sparse macrotrichia; costal fringe abundant but the trichia very tiny and appressed; no trichia on veins beyond cord excepting very sparse microscopic ones on R_5 and in stigmal region of vein $R_1 + Sc_2$. Venation: R_{2+3} unusually long for a member of this group, somewhat variable, ranging from one-third to more than one-half R_{2+3+4}; R_{1+2} and R_2 subequal; m-cu close to fork of M (male) or slightly beyond this fork (female).

Abdomen brownish gray, including hypopygium. Ovipositor with small fleshy valves, as in the group.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 3,500 feet, August 17, 1931 (*Franck*). Allotopotype, female, pinned with type. Paratopotype, female, August 16, 1931 (*Franck*).

The closest ally of the present fly is the Nearctic *Hexatoma* (*Eriocera*) *longicornis* (Walker), which has the antennæ of the female 11-segmented, the flagellum of the male antenna with abundant conspicuous spines, the costal border of the wings strongly darkened, and numerous other characters. The species differs from the two other Asiatic members of the *longicornis* group, *nudivena* sp. nov. and *subpusilla* sp. nov., in the distinct stigmal area and the venation, especially the long R_{2+3}, which is always much longer than R_2 alone. The clear yellow costal border of the wings and the presence of nine antennal segments in the female provide other characters for the ready separation of the species.

HEXATOMA (ERIOCERA) NUDIVENA sp. nov. Plate 1, fig. 19.

Belongs to the *longicornis* group; general coloration of body brown, the præscutum with three slightly darker brown stripes; pleura and coxæ pruinose; wings with a strong dusky tinge; stigma lacking; macrotrichia of veins very sparse or lacking; outer medial veins subobsolete.

Female.—Length, about 9 millimeters; wing, 11.2.

Rostrum and palpi black. Antennæ broken beyond the third segment, black. Head brownish black; vertical tubercle long and conspicuous.

Mesonotum uniform medium brown, the præscutum with three somewhat darker, ill-defined stripes; scutellum gray pruinose. Thorax with only very short blackened setæ. Pleura black, heavily gray pruinose. Halteres short, brownish black throughout. Legs with the coxæ gray pruinose; trochanters black; femora obscure brownish yellow, the tips blackened; remainder of legs black. Wings (Plate 1, fig. 19) with a strong dusky tinge; stigma lacking; veins brown. Macrotrichia of veins very sparse; costal fringe short but abundant; no trichia on veins beyond cord excepting a scanty series on distal section of R_5. Venation: Crossvein h arcuate; R_{2+3+4} and R_3 subequal; R_{1+2} a little longer than R_2; R_{2+3} very short to subobsolete; outer medial veins tending to become obsolete, the distal two-thirds of M_3 and M_4 scarcely evident; m-cu subequal to distal section of Cu_1, placed just beyond fork of M.

Abdomen dark brown, more or less pruinose. Ovipositor with fleshy valves, the hypovalvæ longer than the cerci, moderately sheathing.

Habitat.—China-Tibet border.

Holotype, female, Zya-Ha Pass, altitude 14,000 to 17,000 feet, July 25 to 27, 1930 (*Graham*).

By Edwards's key to the Old World species of *Eriocera*[4] the present fly runs to the second half of couplet 11, where it disagrees with all further species in the fleshy valves of the ovipositor. This fly, with *luteicostalis* sp. nov., and *subpusilla* sp. nov., are unquestionably members of the *longicornis* group which Edwards was inclined to place in the typical subgenus *Hexatoma* rather than in *Eriocera*, despite the retention of three outer medial veins in all members of the group.

[4] Ann. & Mag. Nat. Hist. IX 8 (1921) 70–78.

HEXATOMA (ERIOCERA) SUBPUSILLA sp. nov. Plate 1, fig. 20.

Belongs to the *longicornis* group; general coloration gray; antennæ (female) 6-segmented; mesonotal præscutum with three darker gray stripes; legs pale brown, the femoral tips narrowly brownish black; wings pale grayish, entirely immaculate; R_{2+3+4} longer than R_3; R_2 just beyond fork of R_{2+3+4}.

Female.—Length, about 8 millimeters, wing, 8.

Mouth parts and palpi much reduced. Antennæ only 6-segmented, brown, the basal three segments somewhat paler brown; flagellar segments decreasing in length outwardly, the terminal segment only about one-third to one-half the length of the fifth. Head gray, the vertical tubercle very poorly developed.

Mesonotum light gray, the præscutum with three darker gray stripes that are very poorly delimited against the ground. Pleura gray, the dorsopleural membrane dusky. Halteres pale. Legs with the coxæ gray; remainder of legs pale brown, the tips of femora narrowly brownish black. Wings (Plate 1, fig. 20) uniformly pale grayish, with no costal brightening, entirely immaculate; veins brown. Costal fringe reduced to abundant small setæ; trichiation of veins beyond cord reduced to a scattered series on distal two-thirds of R_5 and a few on vein $R_1 + Sc_2$ in region usually occupied by stigma. Venation: Rs angulated at origin; R_{2+3+4} longer than R_3; R_2 just beyond fork of R_{2+3+4}, a trifle shorter than R_{1+2}; m-cu shortly beyond fork of M, subequal to or a trifle shorter than the distal section of Cu_1.

Abdomen dark brown, the genitalia obscure brownish yellow. Ovipositor with short fleshy valves, the hypovalvæ exceeding the small cerci.

Habitat.—China (Szechwan).

Holotype, female, Mount Omei, altitude 4,000 feet, August 13, 1931 (*Franck*).

By Edwards's key to the Old World species of the subgenus, *Hexatoma* (*Eriocera*) *subpusilla* runs to the African *H.* (*E.*) *pusilla* (Alexander). It is quite different from *H.* (*E.*) *luteicostalis* sp. nov. in the reduction in number of antennal segments, the unbrightened costal region, entire lack of a stigmal area, and, especially, the details of venation, as the brevity of R_{2+3}, shortness of cell R_3, and the basal position of m-cu. From *H.* (*E.*) *nudivena* sp. nov. it differs in the small size, much paler wings, and the details of venation.

HEXATOMA (ERIOCERA) KARIYAI sp. nov. Plate 1, fig. 21; Plate 2, figs. 34 to 36.

Belongs to the *rubrescens* group; general coloration black, gray pruinose; antennæ short in both sexes; wings heavily patterned with dark brown, including cells C and Sc and broad seams along cord and longitudinal veins; Rs in alignment with R_5; male hypopygium with a conspicuous hairy tubercle on either side of midline of caudal margin of eighth sternite; ædeagus at apex split into two slender fimbriate arms.

Male.—Length, about 16 to 17 millimeters; wing, 12 by 3.9; antenna, about 3.

Female.—Length, about 25 millimeters; wing, 15 by 5.

Described from alcoholic specimens.

Rostrum and palpi black. Antennæ of male 7-segmented, of female, 11-segmented, black throughout; flagellar segments (male) gradually decreasing in length and diameter to end; in female, terminal segment about as long as the two preceding segments combined; flagellar segments with long coarse black setæ. Head black, with conspicuous black setæ.

Thorax, including halteres, black, in female apparently more grayish pruinose. Legs black, the femoral bases very broadly more yellowish brown or brown, very extensively so on the posterior legs where only the distal sixth is blackened, on forelegs with the outer fifth blackened. Wings (Plate 1, fig. 21) broad, especially in female; ground color brownish yellow, heavily patterned with blackish, including cells C and Sc, prearcular region, and stigma; other large seams include origin of Rs, cord, outer end of cell 1st M_2, and most longitudinal veins, excepting Cu; anal cells streaked with dusky; veins brown. Macrotrichia of veins very sparse, with a restricted series on outer section of R_5. Venation: Rs in alignment with the basal section of R_5, R_{2+3+4} departing at a strong angle, the fork thus asymmetrical; cell 1st M_2 elongate, equal to distal section of M_{1+2}, the other outer branches of M progressively shorter; m-cu one-half to one-third longer than the distal section of Cu_1.

Abdomen black, with a gray pruinosity, most evident in female. Male hypopygium (Plate 2, fig. 34) with the ædeagus, *a*, relatively long, at apex split into two delicately fringed branches. Eighth sternite, 8*s*, with two closely applied submedian tubercles that are densely set with long coarse setæ. Ovipositor about intermediate in structure between the elongate sclerotized and shorter fleshy types; cerci black, elongate, yet not highly polished; hypovalval plate single, at apex split into two paler setiferous lobes.

Habitat.—Japan (Honshiu).

Holotype, alcoholic male, Gifu, Mino, May 17, 1931 (*Kariya*). Allotopotype, alcoholic female. Paratopotype, alcoholic male.

Hexatoma (*Eriocera*) *kariyai* is named in honor of Prof. S. Kariya, entomologist of the Nawa Entomological Laboratory, to whom I am indebted for many Tipulidæ from Mino Province. The species is closest to *H.* (*E.*) *kamiyai* (Alexander) and *H.* (*E.*) *subrectangularis* (Alexander), both of Japan, in the general pattern of the wings, including the darkened costal border, differing in the large size and structure of the male hypopygium. The coloration in alcohol is distinctly pruinose, and if this is a natural condition, the fly is very different from *kamiyai* in which the entire body is intense velvet-black. The ædeagi of the male hypopygia of *kamiyai* (Plate 2, fig. 35, *a*, holotype) and *subrectangularis* (Plate 2, fig. 36, *a*, paratype) are shown for comparison with the present fly.

HEXATOMA (ERIOCERA) PLESKEI sp. nov. Plate 1, fig. 22.

Belongs to the *rubrescens* group; general coloration black, the præscutum light gray, with four more blackish gray stripes; antennæ short in both sexes; legs and halteres black; wings with a strong yellowish brown tinge, the cord a little clouded with darker; macrotrichia of veins beyond cord very sparse; abdomen dull black, sparsely pruinose.

Male.—Length, 12 to 14 millimeters; wing, 12 to 13.

Female.—Length, 15 to 16 millimeters; wing, 12 to 14.

Rostrum and palpi black. Antennæ short in both sexes, black throughout, 7-segmented in male, 11-segmented in female. Head brownish gray, the vertical tubercle clearer gray, relatively small in both sexes, in male weakly notched; head with abundant long black setæ.

Mesonotum light gray, the præscutum with four more blackish gray stripes; setæ relatively long, dark-colored; scutum with centers of lobes extensively darkened. Pleura black, pruinose. Halteres black. Legs with the coxæ and trochanters black, pruinose; remainder of legs black. Wings (Plate 1, fig. 22) with a strong yellowish brown tinge, the costal region a little darker; stigma small, oval, dark brown; a scarcely apparent darker brown cloud along cord; veins dark brown. Macrotrichia of veins beyond cord very sparse or lacking, with a scattered series of about ten relatively long trichia on distal section of vein R_5. Venation: R_{2+3} more than twice R_{2+3+4} and about two-thirds to three-fourths R_3 alone; cell M_1 lacking; m-cu near midlength of cell 1st M_2.

Abdomen, including hypopygium, dull black, very sparsely pruinose; extreme bases of tergites and the subbasal impressed transverse lines narrowly polished black. Ovipositor black throughout; cerci sclerotized, slender, the tips obtuse.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Tigrowaja, Suchan district, June 16, 1927 (*Stackelberg*). Allotopotype, female, June 11, 1927. Paratopotypes, 5 males and females, June 8 to 16, 1927; paratypes, 1 male, 1 female, Sedanka River, near Wladiwostok, April 20, 1927 (*Martynov*).

I take great pleasure in dedicating this distinct *Eriocera* to Dr. Theodore Pleske, distinguished dipterologist and ornithologist, to whom I express my indebtedness for many kindly favors. Among the regional species of the group, the only other with entirely black legs is *Hexatoma* (*Eriocera*) *longifurca* (Alexander), of Japan, which differs conspicuously from the present fly in the more yellowish wings that are conspicuously variegated with brown, and in the more grayish pruinosity covering the entire body.

HEXATOMA (ERIOCERA) PYRRHOPYGA sp. nov. Plate 1, fig. 23; Plate 2, fig. 37.

Belongs to the *mesopyrrha* group; mesonotal præscutum deep reddish brown with three dark brown stripes; remainder of notum and pleura dark liver brown; femora yellow, the tips black, narrowest on fore and middle femora, more broadly so on posterior legs; wings with the ground color brown, the base and a broad diffuse band before cord yellow; distal half of cell C dark brown; costa nearly glabrous, as in group; abdomen with segments two to four orange, five to seven black, eight and nine reddish yellow.

Male.—Length, about 18 to 22 millimeters; wing, 17 to 21; antenna, 4.8 to 5.2.

Rostrum and palpi dark brown. Antennæ (male) 7-segmented; scape and pedicel dark brown, flagellum yellow throughout; flagellar segments gradually decreasing in length and size outwardly, the black verticils long and conspicuous. Head dark brownish gray; vertical tubercle of moderate size, entire, with black setæ.

Ground color of mesonotal præscutum deep reddish brown, restricted by three dark brown stripes; posterior sclerites of notum and pleura deep liver-brown to dark brown. Halteres dark brown. Legs with the coxæ and trochanters brownish black; femora yellow basally, the tips conspicuously blackened, very narrowly so on fore and middle legs where the distal fifth or sixth is included, much broader on the posterior legs where the distal two-thirds or more is blackened; tibiæ obscure yellow to brownish yellow, the tips narrowly brownish black; tarsi brownish black. Wings (Plate 1, fig. 23) with the ground color brown, the costal region orange, the distal half of cell C abruptly dark brown; a broad diffuse yellow crossband before cord; prearcular region yellow; veins brown, yellow in the flavous areas. Trichiation about as in other members of the group, the costal series very sparse; trichia on veins R_{1+2}, R_3, R_4, and R_5 beyond cord. Venation: R_{1+2} very long, subequal to or exceeding twice m-cu.

Abdomen with basal segment brownish black, segments two to four orange, the tergites margined posteriorly with black, more broadly so on fourth segment; segments five to seven black; outer segments, including hypopygium, reddish yellow. Male hypopygium (Plate 2, fig. 37) with the outer dististyle glabrous, the surface with oblique parallel striæ or wrinkles, apical notch distinct, terminal spine slender and decurved; gonapophyses bifid.

Habitat.—China (Fukien).

Holotype, male, Foochow (*Kellogg*). Paratopotypes, 2 males.

Hexatoma (*Eriocera*) *pyrrhopyga* is allied to the regional *H.* (*E.*) *kelloggi* (Alexander), *H.* (*E.*) *muiri* (Alexander), and *H.* (*E.*) *prælata* (Alexander), differing from all in the reddish yellow hypopygium, which contrasts conspicuously with the black subterminal abdominal segments. In the general coloration of the body, the fly comes closest to *prælata,* being entirely different from the two other species above listed; *H.* (*E.*) *cæsarea* (Alexander) likewise belongs to this group, but is readily distinguished from the other members by the lack of a pale crossband on the wing disk.

HEXATOMA (ERIOCERA) CLEOPATRA sp. nov. Plate 1, fig. 24.

Belongs to the *dichroa* group; thorax brownish black or black; antennal flagellum reddish brown; legs dark brown; wings with a strong brownish yellow tinge, with a broad but very poorly defined more yellowish band before cord; cells C and Sc not darkened; costa with very numerous small trichia; veins beyond cord with trichia; cell M_1 present; abdominal segments one and five to seven black, the remainder orange.

Female.—Length, about 27 millimeters; wing, 21.

Rostrum and palpi dark brown. Antennæ with the scape dark brown, succeeding three segments more reddish brown, terminal segments broken; verticils conspicuous, black. Head blackish gray; vertical tubercle small and simple.

Thorax almost entirely very dark brownish black or black, the extreme cephalic portion of præscutum variegated by reddish on either side of a capillary dark median vitta; thoracic setæ black. Halteres reddish brown, the knobs dark brown. Legs with the coxæ and trochanters black; remainder of legs very dark brown. Wings (Plate 1, fig. 24) with a strong brownish yellow tinge; a broad but very poorly defined, more yellowish band before cord; cells C and Sc not darker than the ground; veins chiefly yellow. Macrotrichia of costa very numerous but short; macrotrichia on veins beyond cord, including complete series on $R_1 + Sc_2$, R_{1+2}, R_{2+3+4}, R_{2+3}, R_3, R_4, and both sections of R_5; on outer medial veins trichia are present but more scattered; a few on distal two-thirds of Rs. Venation: Sc long, Sc_2 ending beyond R_2; R_{2+3+4} one-half longer than basal section of R_5; R_2 slightly oblique; R_{1+2} from one-third to one-half longer than R_{2+3}; cell M_1 present.

Abdomen with basal tergite black, the caudal margin narrowly orange; segments two to four, inclusive, orange, the pleural membrane darkened; segments five to seven black; eighth segment and shield of ovipositor bright orange; valves elongate, horn-yellow.

Habitat.—China (Szechwan).

Holotype, female, Mount Omei, altitude 7,000 feet, August 11, 1931 (*Franck*).

By Edwards's key to the Old World species of *Eriocera*[5] this fly runs to couplet 42, beyond which point it disagrees with all included members in the yellowish wings and coloration of antennæ. If the unusually diffuse band on the wings is considered as being distinct, the fly runs further to couplet 86, including *bicolor* (Macquart) and *cingulata* (de Meijere), which are very different species. In its general appearance, the present fly is much like certain members of the *mesopyrrha* group, notably *cæsarea* (Alexander); but the presence of abundant costal trichia and undarkened costal region serve to separate the two species.

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[5] Ann. & Mag. Nat. Hist. IX 8 (1921) 70–78.

ILLUSTRATIONS

[*a*, Ædeagus; *b*, basistyle; *g*, gonapophysis; *i*, interbase; *id*, inner diststyle; *od*, outer dis-distyle; *p*, phallosome; *s*, sternite; *t*, tergite.]

PLATE 1

FIG. 1. *Tipula* (*Acutipula*) *oncerodes* sp. nov., venation.
2. *Tipula* (*Acutipula*) *latifasciata* sp. nov., venation.
3. *Tipula amytis* sp. nov., venation.
4. *Tipula vitiosa* sp. nov., venation.
5. *Tipula vivax* sp. nov., venation.
6. *Pseudolimnophila brunneinota* sp. nov., venation.
7. *Limnophila* (*Idioptera*) *ussuriana* sp. nov., venation.
8. *Limnophila* (*Dicranophragma*) *melaleuca* sp. nov., venation.
9. *Limnophila* (*Dicranophragma*) *lætithorax* sp. nov., venation.
10. *Limnophila martynovi* sp. nov., venation.
11. *Hexatoma* (*Eriocera*) *lanigera* sp. nov., venation.
12. *Hexatoma* (*Eriocera*) *tibetana* sp. nov., venation.
13. *Hexatoma* (*Eriocera*) *mediofila* sp. nov., venation.
14. *Hexatoma* (*Eriocera*) *stackelbergi* sp. nov., venation.
15. *Hexatoma* (*Eriocera*) *gifuensis* sp. nov., venation.
16. *Hexatoma* (*Eriocera*) *verticalis* (Wiedemann), venation.
17. *Hexatoma* (*Eriocera*) *omeiana* sp. nov., venation.
18. *Hexatoma* (*Eriocera*) *luteicostalis* sp. nov., venation.
19. *Hexatoma* (*Eriocera*) *nudivena* sp. nov., venation.
20. *Hexatoma* (*Eriocera*) *subpusilla* sp. nov., venation.
21. *Hexatoma* (*Eriocera*) *kariyai* sp. nov., venation.
22. *Hexatoma* (*Eriocera*) *pleskei* sp. nov., venation.
23. *Hexatoma* (*Eriocera*) *pyrrhopyga* sp. nov., venation.
24. *Hexatoma* (*Eriocera*) *cleopatra* sp. nov., venation.

PLATE 2

FIG. 25. *Tipula* (*Acutipula*) *bipenicillata* Alexander, male hypopygium, details.
26. *Tipula* (*Acutipula*) *desidiosa* sp. nov., male hypopygium, details.
27. *Tipula* (*Acutipula*) *oncerodes* sp. nov., male hypopygium, details.
28. *Tipula* (*Indotipula*) *subyamata* sp. nov., male hypopygium, details.
29. *Tipula* (*Indotipula*) *yamata* Alexander, male hypopygium, details.
30. *Pseudolimnophila brunneinota* sp. nov., male hypopygium.
31. *Limnophila* (*Idioptera*) *ussuriana* sp. nov., male hypopygium.
32. *Limnophila* (*Dicranophragma*) *lætithorax* sp. nov., male hypopygium.

FIG. 33. *Hexatoma* (*Eriocera*) *gifuensis* sp. nov., male hypopygium.

34. *Hexatoma* (*Eriocera*) *kariyai* sp. nov., male hypopygium.

35. *Hexatoma* (*Eriocera*) *kamiyai* (Alexander), male hypopygium, ædeagus.

36. *Hexatoma* (*Eriocera*) *subrectangularis* (Alexander), male hypopygium, ædeagus.

37. *Hexatoma* (*Eriocera*) *pyrrhopyga* sp. nov., male hypopygium.

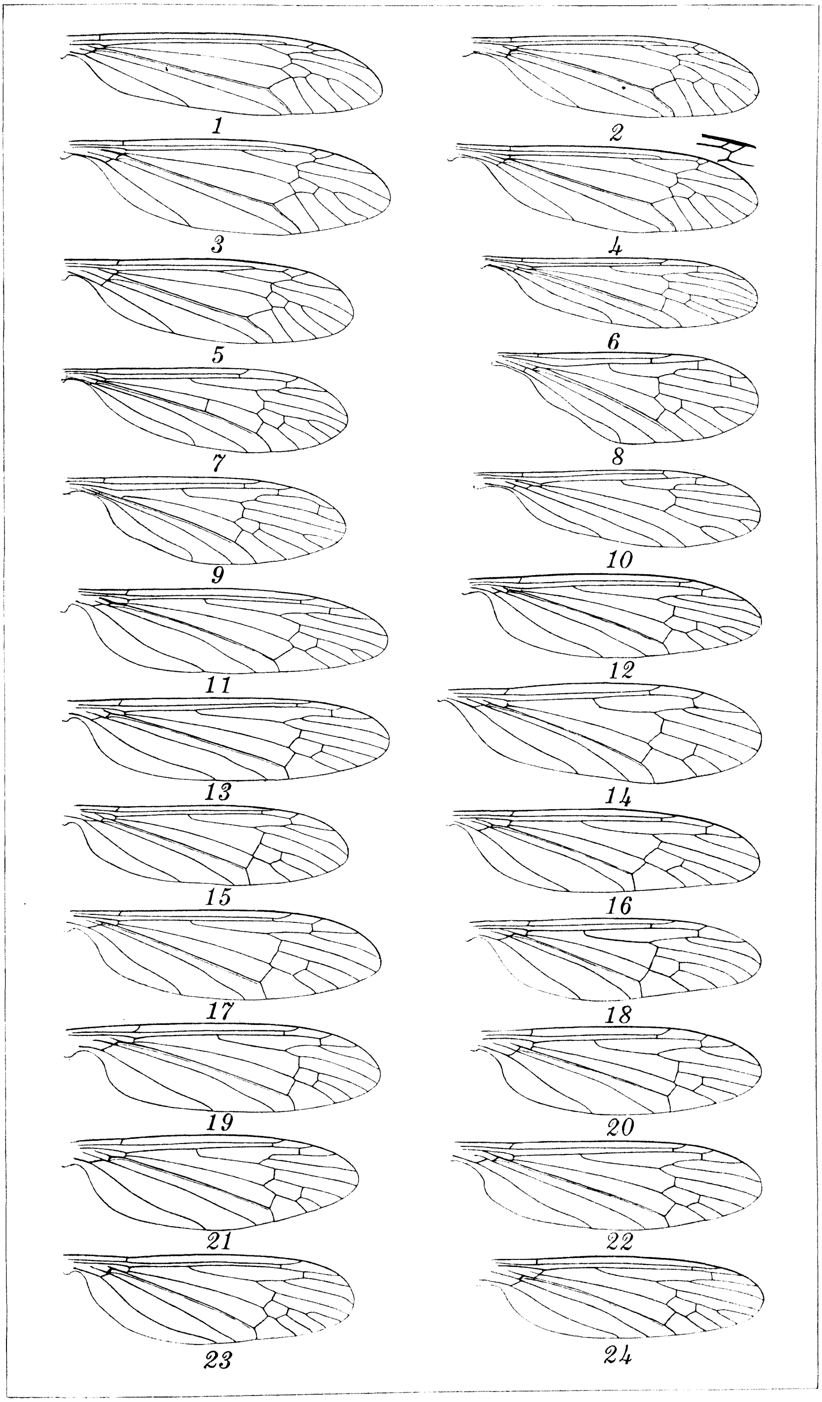

PLATE 1.

TREMATODE PARASITES OF PHILIPPINE VERTEBRATES, VI

DESCRIPTIONS OF NEW SPECIES AND CLASSIFICATION

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SIX PLATES

In this paper, which constitutes the sixth of a series dealing with the trematode fauna of Philippine vertebrates, it has been decided to include among others the descriptions of several parasites that are represented in our collection by single mounted specimens. Many of these have been kept for several years, with the hope that additional material would come to hand. Now they are named and described with no further delay.

DESCRIPTIONS

DIPLODISCUS AMPHICHRUS sp. nov. **Plate 1, figs. 1 and 2.**

The material consists of two sets of specimens collected from frogs: three small, young adults from the small intestine and five large, fully mature forms from the rectum. Due to differences in size, shape, and habitat the two sets of specimens were considered in the beginning to represent distinct species. A comparison of their important characters, however, such as the degree of development of the pharyngeal pockets and œsophageal bulb, the distribution of the vitelline glands, the presence of one testis, the position of the genital pore and the posterior extent of the intestinal cæca, has shown that they are identical.

In his recent revision of the amphistomatous flukes, Fukui (1929) recognizes four species in the genus *Diplodiscus* Diesing: namely, *D. subclavatus* (Goeze, 1782), *D. cornu* (Diesing, 1840), *D. temperatus* Stafford, 1906, and *D. americanus* (Chandler, 1923). To these should be added three other species; but, according to Hardwood (1932), only *D. intermedius* Hunter, 1930, is valid, the other two (*Opisthodiscus americanus* Holl, 1928, and *Megalodiscus ranophilus* Millzner, 1924) being considered as synonyms of *D. temperatus*. Fuhrmann (1928), Fukui, and others also consider Chandler's genus *Megalodiscus* as identical with *Diplodiscus*, but according to Hardwood it should be retained to include the American representatives of the subfamily Diplodiscinæ.

The present form appears to be most closely related to *D. subclavatus*, especially, in the possession of a single testis and in the degree of development of the vitelline glands. It differs from it in the small size of its eggs and, above all, in the position of its genital pore and cirrus sac, which lie some distance behind the œsophageal bifurcation, and in the fact that the vitelline glands meet anteriorly in the median line.

Description.—Body conical, circular or oval in cross-section depending upon state of contraction and method of killing; measures 1.6 to 3.3 millimeters in length by 0.6 to 0.86 millimeter in maximum diameter. Cuticle smooth. Oral sucker ventro-antero-terminal, 0.11 to 0.26 by 0.10 to 0.32 millimeter in size. Oral diverticula (pharyngeal pockets) arise from posterodorsal wall of oral sucker and extend posteriorly; they possess a common medial wall and each is as long as the oral sucker. Œsophagus 0.27 to 0.44 millimeter long, double-walled, passes ventral to pharyngeal pockets and posteriorly it enlarges somewhat to form an inconspicuous bulb. Intestinal cæca simple, moderately wide in diameter, extend to as far as anterior border of posterior sucker, sometimes slightly in front or beyond that level. Posterior sucker posteroterminal, well developed, 0.50 to 1.08 millimeters across, depending upon state of contraction; it presents in its center a small suckerlike structure, measuring 0.10 by 0.13 millimeter across.

Only a single testis is present; it is roundish or slightly oval, median, preovarial, equatorial, 0.14 to 0.46 by 0.12 to 0.46 millimeter in size. Cirrus sac small, oval, 0.12 to 0.22 by 0.10 to 0.14 millimeter in size. Genital pore median, immediately behind anterior third of body length, 0.13 to 0.5 millimeter behind œsophageal bifurcation.

Ovary relatively small, oval, to one side of median line, immediately posttesticular, 0.12 to 0.24 by 0.10 to 0.21 millimeter in size. Shell gland and oötype median, behind ovary; Laurer's canal present, opens dorsally opposite ovary. Uterus short to moderately long, confined between cæca and vitelline glands. Vitellaria in large distinct follicles, lateral and ventral to intestinal cæca, extending from level of œsophageal bulb (in some young specimens sometimes from immediately behind oral diverticula) to posterior sucker or in front of that level. The vitelline follicles meet in the median line both anteriorly and posteriorly; that is, in front of genital pore and behind ovary, sometimes crowding out the latter. Eggs few to many, oval, yellowish, thin-shelled, operculated, 104 to 112 by 62.4 to 70.7 microns in size.

Excretory vesicle median, immediately or a short distance in front of posterior sucker; excretory pore opens dorsally at about the same level. The lymph system could not be made out in detail. In some of the preparations, however, there are distinctly visible two ventral longitudinal vessels on each side of the body, which take a more or less zigzag cephalic course starting from in front of the excretory vesicle. They seem to arise from a short median longitudinal trunk and on reaching the level immediately behind the oral diverticula each vessel makes a sharp bend and is continued posteriorly as a dorsal vessel.

Specific diagnosis.—Diplodiscus: Body conical, 1.6 to 3.3 by 0.6 to 0.86 millimeters in size. Testis single, roundish to oval, median, equatorial, 0.14 to 0.46 by 0.12 to 0.46 millimeter in size. Œsophagus 0.27 to 0.44 millimeter long, with an inconspicuous posterior bulb. Genital pore behind anterior third of body length, some distance behind œsophageal bifurcation. Vitellaria well developed, from level of œsophageal bulb, sometimes from behind oral diverticula, to posterior sucker or in front of that level; vitelline follicles of two sides meet in median line both anteriorly and posteriorly. Eggs 104 to 112 by 62.4 to 70.7 microns in size.

Hosts.—Frogs (*Rana* spp.).

Locations.—Usually rectum; rarely small intestine.

Localities.—Los Baños, Laguna Province (type locality); Novaliches, Rizal Province; and Manila, P. I.

Type specimens.—Philippine Bureau of Science parasitological collection No. 383.

NEPHROSTOMUM BICOLANUM sp. nov. Plate 2, figs. 1 and 2.

Numerous specimens of this fluke were obtained on several occasions from the small intestines of two kinds of egrets. The worm is similar in many respects to *Nephrostomum ramosum* (Sonsino, 1895), as described by Dietz (1910) and by Odhner (1910), differing only from the European species in the absence of a shallow inlet or depression ("Einbuchtung") on the dorsal or anterior border of the cephalic collar and in the relative sizes of the collar spines, especially the innermost corner ones, which in many specimens are very small or degenerate.

Description.—Body elongate, slightly tapering toward both extremities, 8.10 to 15.15 millimeters in length by 1.40 to 2.40 millimeters in maximum breadth across genital organs; anterior region separated from rest of body by slight constriction at level of acetabulum, its lateral margins inrolled ventrally. Cuticle smooth. Cephalic collar reniform, rounded dorsally, that is without dorsal depression, 1.08 to 1.40 millimeters across, carrying forty-seven blunt spines arranged peripherally in one row uninterrupted dorsally. Four to five corner ventral spines on each side of collar often bunched together and measure 41 to 58 by 16.6 to 33.2 microns; in many specimens, however, some of these spines, at least the first two or three innermost ones on one or both sides, are much reduced and measure only 16.6 to 25 by 12.5 to 20.8 microns; the lateral spines, eleven to twelve in number, are the largest, 45.7 to 62.5 by 29.1 to 37.5 microns; dorsal spines 33.2 to 45.7 by 16.6 to 29.1 microns. Oral sucker ventroterminal, 0.26 to 0.28 by 0.28 to 0.36 millimeter in size; pharynx 0.24 by 0.22 to 0.24 millimeter; œsophagus 0.32 to 0.56 millimeter long, bifurcates in front of acetabulum; intestinal cæca simple, reach to near posterior end of body. Acetabulum 1.04 to 1.54 millimeters from anterior end and measures 1.04 to 1.34 by 1.10 to 1.44 millimeters.

Testes relatively small, tandem, postovarial, four- to six-lobed, 0.46 to 1.44 by 0.32 to 0.66 millimeters in size. Cirrus sac oval, 0.36 to 0.56 by 0.30 to 0.38 millimeter, its greater bulk in front of anterior border of acetabulum; incloses vesicula seminalis, pars prostatica, and cirrus. Genital pore median, preacetabular, immediately behind œsophageal bifurcation.

Ovary median, at or near middle of body length, 0.24 to 0.54 by 0.30 to 0.64 millimeter in size, its surface smooth or slightly indented; oviduct arises from its posterior border. Oötype complex median, behind and contiguous to ovary; shell gland as large as ovary or larger. Receptaculum seminis absent, Laurer's canal present. Uterus moderately to very long, in closely packed coils between ovary and acetabulum. Vitellaria lateral, mostly extracæcal, extend from slightly behind acetabulum to near posterior end of body or as far as blind terminations of intestinal cæca; vitelline follicles of two sides do not unite behind second testis. Eggs oval, yellowish, thin-shelled, operculated, 95.5 to 104 by 60 to 62 microns in size.

Excretory pore median, posterodorsal; excretory bladder long, with several pairs of lateral branches, divides into two main branches a short distance behind second testis.

Specific diagnosis.—Nephrostomum: Body 8.10 to 15.15 by 1.40 to 2.40 millimeters in size. Head collar 1.08 to 1.40 millimeters across, without dorsal depression, armed with forty-seven blunt spines. Four to five corner ventral spines on each side of collar often bunched together, measure 41 to 58 by 16.6 to 33.2 microns; sometimes they are much reduced, at least the first two or three on one or both sides, and measure only 16.6 to 25 by 12.5 to 20.8 microns; lateral spines 45.7 to 62.5 by 29.1 to 37.5, dorsal spines 33.2 to 45.7 by 16.6 to 29.1 microns. Eggs 95.5 to 104 by 60 to 62 microns in size.

Hosts.—Herodias timoriensis (type host) and *Bubulcus coromandus.*

Location.—Small intestine.

Locality.—Iriga, Camarines Sur, Luzon (type locality), and Palo, Leyte.

Type specimens.—Philippine Bureau of Science parasitological collection No. 317; paratypes No. 369.

ACANTHOPARYPHIUM OCHTHODROMI sp. nov. Plate 2, figs. 3 and 4.

Sixteen specimens of this echinostome were collected from the small intestines of two plover birds. The parasite differs from *Acanthoparyphium phoenicopteri* (Luehe, 1898), the type species of the genus, as described by Dietz (1910), in being more elongate, its collar spines smaller, the cirrus pouch longer, the acetabulum between the first and second fourth of the body length, the eggs larger, and the vitelline glands extending anteriorly near the level of the acetabulum. It may also be distinguished from *A. spinulosum* Johnston, 1916, by the anterior extent of its vitellaria, its smaller collar spines, its larger eggs, and the posterior extent of its cirrus sac which does not reach to the level of the ovary.

Description.—Body elongate, more pointed posteriorly than anteriorly, usually slightly constricted at level of acetabulum; measures 3.90 to 5.40 millimeters in length by 0.70 to 0.90 millimeter in maximum breadth across ovary or in front of that level. Cuticle armed with prominent spines from anterior end behind head collar to acetabulum. Oral sucker anterosubterminal, 0.09 to 0.14 by 0.10 to 0.14 millimeter in size, surrounded by head collar. Latter reniform, 0.30 to 0.37 millimeter across, provided with twenty-three spines arranged peripherally in single row uninterrupted dorsally. The two innermost ventral corner spines of the head collar are the smallest of the series, reaching a maximum size of only 29 by 8.5 microns; the next three or four spines on each side are the largest, measuring 45 to 58.2 by 9 to 12.5 microns; the rest of the collar spines measure 30 to 41.5 by 9 to 10.5 microns. Oral sucker followed by prepharynx 0.03 to 0.05 millimeter long; pharynx 0.08 to 0.12 by 0.06 to 0.11 millimeter in size; œsophagus 0.32 to 0.66 millimeter long, bifurcates in front of acetabulum; cæca simple, narrow in diameter; reach to near posterior end of body. Acetabulum 0.34 to 0.44 by 0.35 to 0.42 millimeter in size, between first and second fourth of body length.

Testes tandem, postovarial, roundish to oval in outline, 0.44 to 0.64 by 0.42 to 0.62 millimeter in size; surface smooth in some of the younger specimens, in older ones more or less deeply notched so that each organ appears three- to six-lobed. Cirrus sac shaped like a bottle with a long neck, 0.75 to 0.92 by 0.12 to 0.14 millimeter, one-third to one-half of its length reaching posteriorly behind acetabulum; incloses seminal vesicle, pars prostatica and protrusible cirrus. Common genital pore median, preacetabular, immediately behind or almost ventral to œsophageal bifurcation.

Ovary slightly compressed or globular, 0.14 to 0.17 by 0.16 to 0.17 millimeter in size, in front of middle of body length, slightly to one side of median line. Shell gland, which is larger than ovary, and the rest of the oötype complex between ovary and anterior testis; receptaculum seminis absent, Laurer's canal present. Uterus short to moderately long, mostly preovarial. Vitellaria mostly lateral and extracæcal, from behind acetabulum to as far as blind ends of intestinal cæca or slightly behind that level; vitelline follicles of two sides unite behind testis or at most are separated only by a narrow space. Eggs oval, yellowish, thin-shelled, operculated, 104 to 116 by 62 to 70 microns in size.

Excretory pore posteroterminal; excretory bladder long, divides into two branches behind second testis.

Specific diagnosis.—Acanthoparyphium: Body 3.90 to 5.40 by 0.70 to 0.90 millimeters, usually constricted at level of acetabulum. Acetabulum 0.34 to 0.44 by 0.35 to 0.42 millimeter, between first and second fourth of body length. Cephalic collar 0.30 to 0.37 millimeter across; innermost ventral corner spines are 29 by 8.5 microns in maximum size, other corner spines 45 to 58.2 by 9 to 12.5, rest of spines 30 to 41.6 by 9 to 10.5 microns. Testes usually three- to six-lobed. Cirrus sac 0.75 to 0.92 by 0.12 to 0.14 millimeter, its posterior end far from ovary. Vitellaria from behind acetabulum to near posterior end of body. Eggs 104 to 116 by 62 to 70 microns in size.

Host.—*Ochthodromus mongolus.*

Location.—Small intestine.

Locality.—Palo, Leyte.

Type specimens.—Philippine Bureau of Science parasitological collection No. 362.

CERCORCHIS CYCLEMIDIS sp. nov. Plate 3, fig. 2.

Only one specimen of this parasite is available for description. It was collected from a turtle and was well preserved for staining. Compared with the already known members of the genus *Cercorchis* Luehe, 1900, as listed and differentiated by Perkins (1928) as well as with those recently described by Hardwood (1932), it appears to be most closely allied to *C. corti* (Stunkard, 1916) and to *C. texanus* Hardwood. It differs from the former, however, in being slightly larger, with a longer œsophagus, metraterm and cirrus sac, and in the two testes being contiguous and touching each other. It may be distinguished from *C. texanus* by its longer œsophagus and cirrus sac and the extent of its vitelline glands that reach anteriorly much beyond the level of the ovary and posteriorly far from the anterior testis.

Description.—Body elongate, tapering slightly towards both extremities, 8.3 millimeters in length by 0.66 millimeter in maximum breadth across any level touching vitelline glands. Cuticle armed with prominent spines from anterior end to near posterior end of body beyond level of second testis. Oral sucker anterosubterminal, smaller than acetabulum, 0.11 by 0.13 millimeter in size; prepharynx absent; pharynx 0.07 by 0.08 millimeter in size; œsophagus 0.30 millimeter long; intestinal cæca simple, reach to near posterior end of body. Acetabulum 0.16 millimeter across, near middle of anterior third of body length or 1.3 millimeters from anterior end.

Testes oval, postovarial, one immediately behind the other and slightly touching, the distance between the posterior end of the body and the posterior border of the second testis being equal to the length of this latter organ; they are separated from the ovary by the greater bulk of uterine coils. The anterior testis measures 0.34 by 0.29 and the posterior testis 0.36 by 0.27 millimeter. Cirrus sac very elongate, about 2.0 millimeters long by 0.14 millimeter wide near distal end, separated from ovary by portion of uterus or a distance of nearly 0.5 millimeter; it incloses a small seminal vesicle, pars prostatica and cirrus. Common genital pore almost in median line, near and in front of acetabulum.

Ovary globular, preëquatorial, almost median, 0.24 millimeter in diameter. Shell gland and oötype immediately postovarial; receptaculum seminis not distinct, Laurer's canal present. Vitellaria in granular follicles, not arranged in separate groups as in many of the members of the genus and have the tendency to pass towards the median line across the intestinal cæca; they extend from about one-third of the distance from the ovary to the acetabulum, in front of posterior end of cirrus sac, to 1.9 millimeters behind posterior border of ovary; the vitelline glands on the left side extend slightly farther anteriorly and posteriorly than those of opposite side. Uterine coils confined between cæca, arranged in two distinct sets, the right descending and left ascending coils; they reach posteriorly almost to the anterior testis and anteriorly to the middle of the length of the cirrus sac. The metraterm is slightly wavy in outline and is nearly one-half as long as the cirrus sac. Ova in distal portion of uterus small, brown, operculated, 31.5 to 33.2 by 18.5 to 20.0 microns in size.

Excretory system typical; excretory pore posteroterminal; excretory bladder long, reaches anteriorly to level of ovary where it divides into two branches.

Specific diagnosis.—*Cercorchis:* Size 8.3 by 0.66 millimeters; cuticle armed with spines from anterior end to near posterior end of body. Oral sucker slightly smaller than acetabulum; prepharynx absent, œsophagus 0.30 millimeter long. Cirrus sac 2.0 millimeters long, metraterm nearly one-half as long. Testes touching. Vitellaria with tendency to pass across cæca, not arranged in separate groups, extend from in front of level of posterior end of cirrus sac to a distance of 1.9 millimeters behind ovary. Descending and ascending coils of uterus distinct. Ova 31.5 to 33.2 by 18.5 to 20.0 microns in size.

Host.—*Cyclemis amboinensis* (Daudin).

Location.—Intestine.

Locality.—Novaliches, Rizal, Luzon.

Type specimen.—Philippine Bureau of Science parasitological collection No. 406 (stained, mounted).

PARADISTOMUM PALOENSIS sp. nov. Plate 4, fig. 2.

The material available consists of a single specimen which was partially damaged during the process of killing. It may be separated from the very closely related Philippine species, *Paradistomum gregarinum* (Tubangui, 1929), by its larger body dimensions and its very short œsophagus.

Description.—Body more or less ovoid, narrower anteriorly than posteriorly, 4.75 millimeters in length by 2.43 millimeters in maximum breadth across equator. Cuticle smooth. Oral sucker subterminal, 0.38 by 0.48 millimeter in size; pharynx 0.16 by 0.20 millimeter; œsophagus very short, practically absent; intestinal cæca very much dilated, extend to about 0.45 millimeter from posterior end of body. Acetabulum between anterior and middle thirds of body length, 0.44 by 0.48 millimeter in size.

Testes oval, symmetrical, immediately postacetabular and preovarial; right testis measures 0.30 by 0.46, left testis 0.34 by 0.46 millimeter. Cirrus sac ventral to œsophageal bifurcation, 0.40 by 0.12 millimeter in size; incloses small seminal vesicle, pars prostatica, and cirrus. Common genital pore median, behind pharynx.

Ovary ovoid, with slightly indented surface, near median line, preëquatorial, 0.34 y 0.26 millimeter in size. Shell gland, which is larger than ovary, and rest of oötype complex median, behind ovary. Uterus mostly behind genital glands; it was ruptured, however, during the process of killing the specimen so that the arrangement of its coils could not be made out. Vitellaria follicular, lateral to intestinal cæca, occupy middle thirds of body length. Eggs small, yellowish to dark brown, operculated, 33 to 37 by 25 microns in size.

Excretory pore posterodorsal.

Specific diagnosis.—*Paradistomum:* Length 4.75, maximum breadth across middle 2.43 millimeters. Cuticle smooth. Œsophagus very short, practically absent. Genital pore immediately postpharyngeal. Eggs 33 to 37 by 25 microns in size.

Host.—*Hydrosaurus pustulosus* (Eschscholtz).

Location.—Gall bladder.

Locality.—Palo, Leyte.

Type specimen.—Philippine Bureau of Science parasitological collection No. 393.

STYPHLODORA RENALIS sp. nov. Plate 4, fig. 4.

Numerous specimens of this fluke were collected from the kidney of a python by Dr. Candido Africa, of the School of Hygiene and Public Health, University of the Philippines. I am indebted to Doctor Africa for the opportunity to study them.

Compared with the other members of the genus *Styphlodora* this parasite appears to be most closely related to *S. serrata* Looss, 1899, especially in the arrangement of the ovary and testes and in the extent and poor development of the vitelline glands. The two species differ, however, in the length of the œsophagus, that of *S. renalis* being very short or practically absent; and in the position of the acetabulum, that of *S. serrata* being located between the anterior and middle thirds of the body length and that of *S. renalis* in the middle of the anterior third of the body length.

Description.—Body small, oval to elongate, broader posteriorly than anteriorly, 2.3 to 4.6 by 0.95 to 1.7 millimeters in size. Cuticle armed with spines from anterior end to near posterior end of body. Oral sucker subterminal to ventroterminal, 0.18 to 0.24 by 0.20 to 0.28 millimeter in size; prepharynx absent; pharynx 0.14 to 0.20 by 0.10 to 0.16 millimeter; œsophagus very short, practically absent; intestinal cæca simple, do not reach near posterior end of body, in the majority of cases only slightly beyond second third of body length. Acetabulum 0.22 to 0.38 by 0.26 to 0.40 millimeter in size, in middle of anterior third of body length.

Testes round to oval or elongate, postovarial, one obliquely behind the other; their surfaces are rarely smooth, often they are more or less distinctly indented so that each organ may present two to five lobes; they measure 0.34 to 0.52 by 0.17 to 0.35 millimeter. Cirrus sac prominent, 0.40 to 0.64 by 0.14 to 0.20 millimeter in size, extends posteriorly beyond acetabulum to ovary; it incloses vesicula seminalis, pars prostatica and cirrus. Genital pore median, in rare cases slightly to one side of median line, immediately preacetabular.

Ovary oval or triangular with rounded angles, smooth, to one side of median line, a short distance behind acetabulum, 0.20 to 0.24 by 0.18 to 0.19 millimeter in size. Oötype complex median, between ovary and anterior testis; shell gland diffuse, poorly developed. Receptaculum seminis gourd-shaped, behind ovary; Laurer's canal present. Vitellaria follicular, scanty, lateral, extend from level of acetabulum to that of anterior testis. Uterus well developed, arranged in descending and ascending coils that partly overlap, mostly posttesticular, reaching posteriorly beyond blind terminations of intestinal cæca. Eggs numerous, oval, yellowish, thin-shelled, operculated, 45.5 to 47.8 by 20.8 to 22.8 microns in size.

Excretory pore posterodorsal.

Specific diagnosis.—*Styphlodora:* Size 2.3 to 4.6 by 0.95 to 1.7 millimeters. Œsophagus very short, practically absent. Acetabulum 0.22 to 0.38 by 0.26 to 0.40 millimeter, in middle of anterior third of body. Cirrus sac 0.40 to 0.64 by 0.14 to 0.20 millimeter, reaches posteriorly to middle of ovary. Eggs 45.5 to 47.8 by 20.8 to 22.8 microns in size.

Host.—*Python reticulatus.*

Location.—Kidney.

Locality.—? Manila, P. I.

Type specimens.—Philippine Bureau of Science parasitological collection No. 299.

CLINOSTOMUM DALAGI sp. nov. Plate 4, fig. 1.

Seven immature specimens of this fluke were received for determination from Dr. Zacarias de Jesus, of the College of Veterinary Science, University of the Philippines, Los Baños, who found them encysted in the eye-sockets and on the pericardial wall of a fish. The adult stage of this worm, as well as that of another species found in frogs, which is also described in this paper, will probably be found in the throats of birds, as is the case with related forms reported in other parts of the world (see Osborn, 1912, and Cort, 1913).

The available literature mentions only three young forms of *Clinostomum* that are adequately described and with which the Philippine species may be compared; namely, *C. dictyotum* (Looss, 1885) (= *C. reticulatum*), *C. marginatum* (Rudolphi, 1815), and *C. attenuatum* Cort, 1913. It is at once distinguished from *C. dictyotum* by the presence of lateral branches on the intestinal cæca, the shape of the ovary, and the posterior extent of its uterine sac. From the other two species it can be separated by the shape of its genital glands, the length and shape of the uterine sac, and the relative sizes of its suckers.

Description.—Body elongate oval, narrower anteriorly than posteriorly, 4.20 to 4.45 by 1.85 to 2.20 millimeters in size. Cuticle armed with minute spines from anterior to posterior end. Oral sucker subterminal to ventroterminal, 0.60 to 0.74 millimeter across, partially retracted in such a way that the anterior body wall is raised around it like a collar. Acetabulum 0.86 to 1.00 millimeter in diameter, very proximate to oral sucker. Pharynx absent; œsophagus very short, practically absent. Intestinal cæca with external and internal lateral branches that are especially prominent in postacetabular region; they reach to near posterior end of body.

Testes tandem, pyramidal with their bases facing each other, with smooth surfaces; they measure 0.18 to 0.30 by 0.48 to

0.56 millimeter; they occupy middle thirds of postacetabular body length, the distance from posterior border of acetabulum to anterior testis and that from second testis to posterior end of body being about the same. What appears to be a small cirrus sac is found on the right of first testis.

Ovary roundish, intertesticular, on right side of median line, 0.16 millimeter across. Shell gland median, larger than and beside ovary. Uterine sac a median longitudinal canal extending from immediately behind acetabulum to first testis. Vitellaria not evident.

Excretory pore dorsal, near posterior end of body.

Specific diagnosis.—Clinostomum: Body elongate oval, 4.20 to 4.45 by 1.85 to 2.20 millimeters in size. Suckers very proximate, the oral smaller than the ventral. Cæca with prominent external and internal lateral branches. Ovary roundish, 0.16 millimeter across. Uterine sac median, longitudinal, from immediately behind acetabulum to first testes.

Host.—Ophiocephalus striatus.

Location.—Encysted in eye-sockets and pericardium.

Locality.—Los Baños, Laguna, Luzon.

Type specimens.—Philippine Bureau of Science parasitological collection No. 277.

CLINOSTOMUM PSEUDOHETEROSTOMUM sp. nov. Plate 3, fig. 1.

Two individuals of this parasite were presented by Dr. D. Villadolid, of the College of Agriculture, University of the Philippines, Los Baños, who found them encysted between the femoral muscles of a frog. The fluke is characterized by the form of its testes, the anterior testis being U-shaped and the posterior V-shaped. In this respect it is similar to the adult *Clinostomum heterostomum* (Rudolphi), as described by Braun (1900). A detailed comparison between the two forms, however, cannot be made, for a description of the corresponding immature stage of the latter is not available.

Description.—Body elongate, slightly tapering towards both ends, 6.6 to 7.2 by 1.8 to 2.0 millimeters in size. Cuticle apparently unarmed. Oral sucker subterminal, 0.60 to 0.64 by 0.70 to 0.80 millimeter in size; it is not retracted, hence neither collar nor oral field is visible. Acetabulum 0.98 to 1.08 by 1.10 to 1.24 millimeters in size, between anterior and middle thirds of body length. Pharynx absent; œsophagus very short, practically absent. Intestinal cæca long, with short lateral branches, extend to near posterior end of body.

Testes tandem, in anterior half of last third of body length; anterior testis U-shaped, measures 0.52 to 0.60 by 0.70; posterior testis V-shaped, 0.50 by 0.54 to 0.62 millimeter.

Ovary small, intertesticular, on right side of median line, 0.16 by 0.12 millimeter in size. Shell gland median, slightly larger than and lateral to ovary. Uterine sac prominent, cylindrical, median, from about 0.3 millimeter behind acetabulum to immediately in front of anterior testis. Vitellaria not evident.

Excretory pore median, on dorsal surface, near posterior end of body.

Specific diagnosis.—Clinostomum: Body elongate, 6.6 to 7.2 by 1.8 to 2.0 millimeters in size. Oral sucker 0.60 to 0.64 by 0.70 to 0.80; acetabulum 0.98 to 1.08 by 1.10 to 1.24 millimeters in size, between anterior and middle thirds of body length. Testes dissimilar: anterior testis U-shaped, posterior testis V-shaped.

Host.—Rana magna.

Location.—Encysted between femoral muscles.

Locality.—Los Baños, Laguna, Luzon.

Type specimens.—Philippine Bureau of Science parasitological collection No. 22.

HAPLORCHIS ANGUILLARUM sp. nov. Plate 4, fig. 3.

Only a single specimen of this fish trematode is available for description. With the exception of its possessing two testes it tallies with the characterization of the genus *Haplorchis* Looss, 1899. The presence of double testes is here considered of specific rather than of generic importance in the same way that among the amphistomatous flukes the number of these organs is used to separate the members of the genus *Diplodiscus.*

Description.—Body small, elongate, 2.9 millimeters in length by 0.56 millimeter in maximum breadth at level of œsophageal bifurcation. Cuticle armed with numerous small spines from anterior end to level midway between second testis and posterior end of body. Oral sucker ventroterminal, 0.15 by 0.18 millimeter in size. Prepharynx 0.34 millimeter long; pharynx 0.14 by 0.16 millimeter in size; œsophagus 0.18 millimeter long, bifurcates in front of genital pore. Intestinal cæca simple, extend to about 0.20 millimeter from posterior end of body. Acetabulum absent.

Testes two, spherical, tandem, immediately postovarial; anterior testis slightly larger, 0.26 millimeter in diameter; posterior testis 0.24 millimeter across. Cirrus pouch absent. Vesicula seminalis free in parenchyma, median, preovarial; it is in the form of a bent sac, constricted near anterior end and measures 0.42 by 0.13 millimeter. A short prostate surrounded by a few prostate glands arises from anterior end of the vesicula seminalis and is followed by an equally short ejaculatory duct. Genital pore median, behind œsophageal bifurcation; it is surrounded by a small genital sucker 0.10 by 0.13 millimeter in size and guarded by five pointed chitinous spines.

Ovary median, slightly compressed, immediately preëquatorial, 0.14 by 0.17 millimeter in size. Oviduct arises from posterior border of ovary. Receptaculum seminis well developed, to right side of median line, between ovary and anterior testis. Laurer's canal not discernible. Vitellaria moderate, somewhat in lattice work, mostly behind second testis but not reaching level of blind ends of intestinal cæca. Vitelline ducts pass anteriorly ventral to testes and meet in median line to form a small roundish vitelline reservoir. Latter and poorly developed shell gland occur alongside receptaculum seminis. Uterus moderately long, mostly posttesticular, arranged in short descending and ascending coils and extend posteriorly beyond terminations of intestinal cæca. No eggs present; instead uterus is filled with brownish granular material.

Excretory pore posteroterminal.

Specific diagnosis.—Haplorchis: Body elongate, 2.9 by 0.56 millimeters in size. Cuticle armed with small spines from anterior end to behind second testis. Testes two, spherical, tandem; anterior testis 0.26, second testis 0.24 millimeter in diameter. Genital pore guarded by five pointed chitinous spines.

Host.—Anguilla mauritiana (Bennet).

Location.—Intestine.

Locality.—Palo, Leyte.

Type specimen.—Philippine Bureau of Science parasitological collection No. 392.

SCAPHANOCEPHALUS ADAMSI sp. nov. Plate 5, fig. 2.

Two members of the genus *Scaphanocephalus* Jaegerskioeld, 1903, have been described; namely, *S. expansus* (Creplin, 1842) and *S. australis* Johnston, 1916. Both of them were obtained in the adult stage from sea eagles in Europe and Australia, respectively. The present form, which is immature, was found encysted in the fins and under the scales of several individuals of *Lepidaplois mesothorax,* a marine fish, that died in the aquarium of the Fish and Game Administration. Specimens were found by members of the Philippine Fish and Game Administration. It is most reasonable to expect from what is known of the development of heterophyid flukes in general that the worm under consideration represents the metacercarial stage of a parasite infesting a fish-eating bird, probably a hawk or an eagle.

Except for the absence of the vitelline glands and eggs in the uterus, the worm has reached such a stage of development that it can very well be compared for purposes of differentiation with its adult relatives. Unfortunately, however, the description of *Scaphanocephalus expansus* is not available to me, hence it will only be compared with *S. australis*. It may be distinguished from the latter by its shorter œsophagus, its branched testes, and lobulated or almost follicular ovary. I have the pleasure of naming this trematode for Mr. Wallace Adams, chief of the Fish and Game Administration, who has shown active interest in the study of parasites infesting fishes in the Philippines.

Description.—The cysts are practically circular discs measuring about 3 millimeters in diameter. Unlike other cysts they are hard, opaque and very resistant to pressure, the walls having the consistency of cartilage. For this reason they are difficult to dissect and from one dozen cysts that were opened only two perfect worms were obtained.

Body characteristically T-shaped due to expanded anterior portion, which is membranous; measures in millimeters 3.02 to 3.07 in length by 2.15 to 2.37 in maximum breadth in anterior region and 1.17 to 1.21 across level of first testis in posterior region. Anterior surface up to level midway between genital pore and ovary armed with very minute spines that are buried in the cuticle. Oral sucker measures 0.12 by 0.11 to 0.13 millimeter, withdrawn from anterior end, followed by pharynx 0.08 to 0.09 by 0.08 millimeter in size. Œsophagus 0.06 to 0.11 millimeter long, divides into two simple narrow cæca that take an irregular zigzag course towards the posterior end. Acetabulum reduced, not distinct from the so-called genital sucker; the combined structures or the ventrogenital sac of Witenberg (1929) measure 0.18 to 0.21 by 0.13 to 0.19 millimeter and occupy a median position in anterior third of body length, about midway between oral sucker and ovary. Genital pore in posterior half of ventrogenital sac.

Testes tandem, postovarial, branched; anterior testis 0.19 to 0.23 by 0.74 to 0.76, posterior testis 0.20 to 0.27 by 0.72 to 0.80

millimeter in size. Vasa efferentia meet at some distance in front of ovary forming a common duct, the vas deferens, which is not much larger in diameter than any of the vasa efferentia. Cirrus sac absent. Shortly before entering the ventrogenital sac, the vas deferens is surrounded for a short distance of its length by unicellular prostatic cells.

Ovary multilobed or follicular, median, immediately postequatorial, measures 0.10 to 0.11 by 0.27 to 0.28 millimeter. Receptaculum seminis and Laurer's canal behind ovary. Shell gland small, at almost the same level as seminal receptacle but on left side of median line. Uterus in loose coils between ventrogenital sac and ovary. Eggs and vitelline glands not yet developed.

Visible portions of excretory and nervous systems very similar in arrangement to those of *Scaphanocephalus australis.*

Specific diagnosis.—Scaphanocephalus: Length 3.02 to 3.07 millimeters, maximum breadth 2.15 to 2.37 across anterior region and 1.17 to 1.21 across first testis in posterior region. Cuticle armed with very minute spines from anterior end to level midway between genital pore and ovary. Œsophagus 0.06 to 0.11 millimeter long. Ovary multilobed or follicular, immediately postequatorial. Testes branched.

Host.—Lepidaplois mesothorax.

Location.—Encysted in fins and under scales.

Locality.—Manila, P. I.

Type specimens.—Philippine Bureau of Science parasitological collection No. 426.

AUSTROBILHARZIA BAYENSIS sp. nov. Plate 1, fig. 3.

This is represented by a single male specimen collected from the migratory snipe, *Gallinago gallinago.* It differs from *Austrobilharzia terrigalensis* Johnston, 1916, in the number of its testes, which is twenty-six, the Australian form possessing only eighteen to twenty.

Description.—Body of male elongate, 5.2 millimeters in length by 0.32 millimeter in maximum width across middle. Cuticle smooth. Oral sucker 0.18 by 0.14 millimeter in size, anteroterminal. Acetabulum 0.22 millimeter in anteroposterior diameter, between first and second seventh of body length. Œsophagus 0.7 millimeter long, bifurcates immediately behind acetabular level. Cæca take a wavy posterior course, uniting at about 1.5 millimeters from posterior end of body; the resulting trunk reaches near posterior extremity. Gynæcophoric canal well developed, extends from immediately behind acetabulum to posterior end of body.

Testes twenty-six in number, spherical or slightly compressed, 66.5 to 87.3 microns across, arranged in longitudinal series from a short distance behind genital pore to middle of body length; the testicular expanse is about 1.5 millimeters. Cirrus pouch flask-shaped, 0.16 by 0.10 millimeter in size; incloses seminal vesicle and prostate. Genital pore on ventral surface, about equidistant between acetabulum and first testis.

Specific diagnosis.—Austrobilharzia: Female unknown. Male 5.2 by 0.32 millimeters in size. Testes twenty-six in number, spherical or slightly compressed, 66.5 to 87.3 microns across.

Host.—Gallinago gallinago.

Location.—Mesenteric vessel.

Locality.—Bay, Laguna, Luzon.

Type specimen.—Philippine Bureau of Science parasitological collection No. 315.

NEODIPLOSTOMUM ALUCONIS sp. nov. Plate 6, fig. 1.

This parasite is represented by several specimens collected from the small intestine of an owl. It bears a superficial resemblance to *Neodiplostomum longum* Brandes, 1890. It differs from it in the extent of its vitellaria which do not reach anteriorly the level of the acetabulum while posteriorly they extend to near the posterior end of the body; in the presence of minute cuticular spines; and in the shape of the testes, the extremities of which are bent ventrally.

Description.—Body with a total length of 3.15 to 5.40 millimeters, divided distinctly into two regions. Cuticle armed with very minute spines from anterior end to at least level of ovary. Forebody flattened, its lateral margins inrolled ventrally and uniting posteriorly behind adhesive disc and in front of junction of fore- and hindbody; it measures 1.25 to 1.62 by 0.54 to 0.92 millimeters. Lateral suctorial cups or earlike appendages absent. Hindbody cylindrical, generally more than twice as long as forebody, measures 1.90 to 3.78 millimeters in length by 0.38 to 0.65 millimeter in maximum diameter across any of the testes. Oral sucker anterosubterminal, 0.054 to 0.075 by 0.058 to 0.066 millimeter in size; pharynx 0.062 to 0.075 by 0.037 to 0.054; œsophagus 0.041 to 0.066 millimeter long; intestinal cæca simple, extend to near posterior end of body. Acetabulum 0.070 to 0.083 by 0.083 to 0.090 millimeter, in middle of length of forebody or immediately in front of that level.

Adhesive disc elongate oval, 0.36 to 0.70 by 0.22 to 0.36 millimeter in size, immediately postacetabular, with a shallow elongate cavity. Adhesive gland not prominent, U-shaped, dorsal to posterior end of adhesive disc.

Testes tandem, postovarial, transversely elongate, sometimes slightly constricted at middle, their extremities bent ventrally; they measure 0.14 to 0.34 by 0.24 to 0.60 millimeter. Vesicula seminalis poorly developed, posttesticular. Genital pore median, dorsal, near posterior end of body.

Ovary transversely ovoid, immediately behind equator of hindbody, 0.10 to 0.16 by 0.12 to 0.34 millimeter in size. Oötype complex intertesticular. Vitellaria profuse, in both body regions, extending from anterior level of adhesive disc to near posterior end of body; they penetrate into adhesive disc. Uterus well developed, confined in hindbody. Eggs oval, yellowish, thin-shelled, operculated, 91.5 to 95.6 by 52 to 58.2 microns in size.

Specific diagnosis.—*Neodiplostomum:* Total length 3.15 to 5.40 millimeters; forebody 1.25 to 1.62 by 0.54 to 0.92, hindbody 1.90 to 3.78 by 0.38 to 0.65. Cuticle armed with minute spines at least up to level of ovary. Testes transversely elongate, 0.14 to 0.34 by 0.24 to 0.60 millimeter, their extremities bent ventrally; ovary 0.10 to 0.16 by 0.12 to 0.34. Vitellaria extend from anterior level of adhesive disc to near posterior end of body. Eggs 91.5 to 95.6 by 52 to 58.2 microns.

Host.—*Aluco longimembris.*

Location.—Small intestine.

Locality.—Obando, Bulacan, Luzon.

Type specimens.—Philippine Bureau of Science parasitological collection No. 150.

APHARYNGOSTRIGEA GARCIAI sp. nov. Plate 6, fig. 2.

This species is named for Mr. Simplicio Garcia, who collected numerous specimens of the parasite from the intestine of an egret. It is readily distinguished from the other members of the genus *Apharyngostrigea* Ciurea, 1927, as described by Szidat (1929), by its multilobulated testes.

Description.—Body 2.8 to 5 millimeters in total length, characteristically strigeid in shape and distinctly divided into two regions. Forebody approximately cubic, with rounded angles, 1 to 1.5 by 1.15 to 1.40 by 1.20 to 1.35 millimeters. Hindbody vase-shaped, constricted off from forebody, expanded in middle, 1.8 to 3.5 by 1.2 to 1.4 by 1 to 1.45 millimeters in dimensions. Oral sucker weak, 0.20 to 0.26 millimeter across, visible through opening of cavity of forebody. Acetabulum also weak, near middle of length of forebody, 0.22 to 0.30 millimeter across. Pharynx absent. Holdfast apparatus well developed, filling up most of cavity of forebody; its component lamellæ have not been ascertained. Adhesive gland median, transversely oval, at junction of two body regions, measuring 0.16 to 0.22 by 0.30 to 0.36 by 0.26 to 0.30 millimeter.

Testes tandem, immediately postovarial, multilobulated, measuring 0.60 to 0.70 by 0.90 to 1.1 by 0.85 to 0.96 millimeters; they partly overlap so that it is sometimes difficult to distinguish them individually. Vesicula seminalis well developed, coiled, median, immediately behind second testis. Genital pore on tip of a genital cone and opens into a genital sinus at posterior end of body.

Ovary median transversely compressed, with smooth surface, in anterior third of hindbody length, 0.22 to 0.40 by 0.48 to 0.68 by 0.45 to 0.50 millimeter in dimensions. Oötype complex intertesticular, as is usual among holostomes; Laurer's canal opens dorsally opposite first testis. Vitellaria well developed, especially in forebody, where the vitelline follicles are profusely distributed; in hindbody they also occupy most of the space not otherwise occupied by the other reproductive structures, reaching to near posterior end of body. Uterus moderately long, confined in hindbody, passing ventral to genital glands. Eggs oval, yellowish, thin-shelled, operculated, 87.5 to 95.6 by 60 to 62.5 microns in size.

Excretory pore slitlike, dorsal, at a level about equidistant between vesicula seminalis and posterior end of body.

Specific diagnosis.—Apharyngostrigea: Total length 2.8 to 5 millimeters; forebody measures 1 to 1.5 by 1.15 to 1.4 by 1.2 to 1.35, hindbody 1.8 to 3.5 by 1.2 to 1.4 by 1 to 1.45 millimeters. Testes multilobulated. Eggs 87.5 to 95.6 by 60 to 62.5 microns in size.

Host.—Herodias timoriensis.

Location.—Small intestine.

Locality.—Iriga, Camarines Sur, Luzon.

Type specimens.—Philippine Bureau of Science parasitological collection No. 355.

TETRACOTYLE BICOLANDIÆ sp. nov. Plate 5, fig. 1.

Various kinds of tetracotyles have been found encysted in mollusks, leeches, and animals of the different classes of vertebrates. These are larval forms, representing the young stages (metacercariæ) of certain strigeid flukes. One species, *Tetracotyle orientalis,* according to Faust (1921), is the larva of *Cyathocotyle orientalis;* while another, *T. communis* Hughes, 1928, according to La Rue (1932), is the young stage of *Cotylurus communis.*

The present form was found encysted in the subcutaneous tissue of the neck of a tern (*Sterna sinensis*). The bird was received in the laboratory already skinned and preserved in formalin solution. The description that follows, therefore, is based entirely on preserved specimens.

Description.—Cyst whitish, opaque, globular to ovoid, 0.60 to 0.75 by 0.40 to 0.70 millimeter in size. Cyst wall composed of two layers; namely, an outer layer, probably of host origin, composed of connective tissue and averaging 0.08 to 0.16 millimeter in thickness; and an inner hyaline layer, probably of parasite origin, 0.008 to 0.02 millimeter thick. Cavity of cyst 0.34 to 0.42 by 0.20 to 0.26 millimeter in size, the greater part occupied by parasite.

Body of worm ovoid, broader anteriorly, 0.28 to 0.36 millimeter in length by 0.20 to 0.25 millimeter in maximum breadth; division of body into anterior and posterior regions as seen in adult holostomes not apparent. Anteriorly there is a small, terminal or subterminal circular opening that apparently leads posteriorly into a potential cavity occupied by adhesive apparatus. Cuticle smooth.

Oral sucker ventral, near anterior end, 0.050 to 0.062 millimeter across. Acetabulum equatorial in position, larger than oral sucker, 0.066 to 0.083 by 0.075 to 0.083 millimeter in size. Pharynx measures 0.025 by 0.033 millimeter, œsophagus very short, divides immediately into two cæcal branches, the posterior extent of which beyond the adhesive organ is not visible.

On each side of pharynx on ventral surface, is an inpocketing of the cuticula, forming a so-called lateral sucker, which is smaller than or almost as large as the oral sucker and has a prominent opening. Adhesive organ large, transversely oval, immediately behind acetabulum, 0.040 to 0.060 by 0.104 to 0.120 millimeter in size; its simple cavity communicates with the exterior through a W-shaped opening. Adhesive gland transversely elongate, prominent in stained specimens, immediately behind adhesive organ, measures 0.023 to 0.037 by 0.070 to 0.100 millimeter.

Rudiment of reproductive system in the form of a globular mass of deeply staining cells, 0.025 to 0.030 millimeter in diameter and located immediately behind adhesive gland.

Main excretory or urinary bladder at posterior portion of body, somewhat V-shaped, opens to exterior through postero-terminal excretory pore. Spaces are visible through cuticle near lateral margins of body that are filled with solid calcareous granules; these probably represent the so-called reserve bladders, described by Hughes (1928, 1929) and others in related parasites.

Specific diagnosis.—Tetracotyle: Cyst globular to ovoid, 0.60 to 0.75 by 0.40 to 0.70 millimeter in size. Body of worm ovoid, broader anteriorly, measures 0.28 to 0.36 by 0.20 to 0.25 millimeter. Cuticle smooth. Oral sucker 0.050 to 0.062 millimeter across; acetabulum equatorial, 0.066 to 0.083 by 0.075 to 0.083 millimeter; pharynx 0.025 by 0.033 millimeter; œsophagus short. Adhesive organ transversely oval, 0.040 to 0.060 by 0.104 to 0.120 millimeter. Adhesive gland transversely elongate, 0.023 to 0.037 by 0.070 to 0.100 millimeter. Genital anlage globular, 0.025 to 0.030 millimeter across.

Host.—Sterna sinensis.

Location.—Encysted in subcutaneous tissue of neck.

Locality.—Iriga, Camarines Sur, Luzon.

Type specimens.—Philippine Bureau of Science parasitological collection No. 318.

SYSTEMATIC LIST OF TREMATODE PARASITES SO FAR REPORTED FROM PHILIPPINE VERTEBRATES

The known species of flukes infesting vertebrates, including man, in the Philippines now total sixty-nine. For the purpose of ready reference these are systematically arranged below together with their hosts.

Class TREMATODA Rudolphi, 1808

Subclass MONOGENEA van Beneden, 1858

Order MONOPISTHODISCEA (Fuhrmann, 1928)

Family GYRODACTYLIDÆ van Beneden and Hesse, 1863

ANCYROCEPHALUS MANILENSIS Tubangui, 1931.

Hosts.—Teuthis virgata, Lutianus lioglossus, Anyperodon leucogrammicus (gills).

TETRANCISTRUM LUTIANI Tubangui, 1931.

Host.—*Lutianus lioglossus* (gills).

Order POLYOPISTHOCOTYLEA Odhner, 1912

Family MICROCOTYLIDÆ Taschenberg, 1879

MICROCOTYLE VIRGATARUM Tubangui, 1931.

Host.—*Teuthis virgata* (gills).

Subclass DIGENEA van Beneden, 1858

Order PROSOSTOMATA Odhner, 1908

Suborder MONOSTOMATA Zeder, 1800

Family CYCLOCŒLIDÆ Kossack, 1911

CYCLOCOELUM (POSTPHARYNGEUM) OBSCURUM (Leidy, 1887).

Host.—*Totanus eurhinus* (cervical air sac).

This was originally described under the name *Cyclocoelium* (*Postpharyngeum*) *orientale* var. *eurhinus* due to its close resemblance to *C. orientale* Skrjabin, 1913 (see Tubangui, 1932). Due to oversight I failed to note that Witenberg (1928) considers Skrjabin's species as well as *C. halcyonis* MacCallum, *C. leidyi* Harrah, *C. obliquum* Harrah and *C. vicarium* (Arnsdorf) as synonyms of *C. obscurum.* If the morphology of the latter is as variable as Witenberg purports to show, there is no justification in retaining the Philippine species as an independent variety.

Family NOTOCOTYLIDÆ Luehe, 1909

NOTOCOTYLUS INTESTINALIS Tubangui, 1932.

Host.—Domestic duck (intestine).

NOTOCOTYLUS NAVIFORMIS Tubangui, 1932.

Host.—Domestic duck (intestine).

Suborder STRIGEATA La Rue, 1926

Superfamily STRIGEOIDEA Railliet, 1919

Family STRIGEIDÆ (Railliet, 1919)

STRIGEA MCGREGORI Tubangui, 1932.

Host.—*Butastur indicus* (intestine).

PARASTRIGEA INTERMEDIA Tubangui, 1932.

Host.—*Butastur indicus* (intestine).

APHARYNGOSTRIGEA GARCIAI sp. nov.

Host.—*Herodias timoriensis* (small intestine).

COTYLURUS MAMILLIFORMIS Tubangui, 1932.

Host.—Snipe (? *Gallinago gallinago*) (intestine).

TETRACOTYLE BICOLANDIAE sp. nov.

Host.—*Sterna sinensis* (encysted in subcutaneous tissue of neck).

Family ALARIIDÆ (Tubangui, 1922) Bosma, 1931

Subfamily NEODIPLOSTOMINÆ Dubois, 1932

PROALARIA BUTASTURINA Tubangui, 1932.

Host.—*Butastur indicus* (small intestine).

Dubois (1932) considers the genus *Proalaria* La Rue, 1926, as a synonym of *Diplostomum* von Nordmann, 1832. In that case this parasite will be known as *Diplostomum butasturinum.*

NEODIPLOSTOMUM ALUCONIS sp. nov.

Host.—*Aluco longimembris* (small intestine).

Superfamily SCHISTOSOMATOIDEA Stiles and Hassall, 1926

Family SCHISTOSOMATIDÆ Looss, 1899

Subfamily SCHISTOSOMATINÆ Stiles and Hassall, 1898

SCHISTOSOMA JAPONICUM Katsurada, 1904.

Host.—Man (portal blood system).

AUSTROBILHARZIA BAYENSIS sp. nov.

Host.—*Gallinago gallinago* (mesenteric vessel).

Suborder AMPHISTOMATA (Rudolphi, 1801)

Family PARAMPHISTOMATIDÆ Fischoeder, 1901

Subfamily PARAMPHISTOMATINÆ Fischoeder, 1901

PARAMPHISTOMUM EXPLANATUM (Creplin, 1847).

Hosts.—Cattle and carabao (rumen).

This was reported by Schwartz (1925). In the same year, without having seen Schwartz's paper, I reported what is apparently the same parasite as *Paramphistomum cervi* (Zeder, 1790). A reëxamination of my material has convinced me that Doctor Schwartz's determination is correct.

I make no distinction in this paper among the various domesticated breeds of cattle and carabaos that exist in the Philippines; such as, *Bos taurus, Bos indicus, Bos kerabau,* and *Bubalus bubalus.* According to my observations native and Indian buffaloes are susceptible to the same kinds of helminths and the same thing is true with respect to native and Indian cattle.

PARAMPHISTOMUM ANISOCOTYLEA Faust, 1920.

Hosts.—Cattle and carabao (? rumen).

COTYLOPHORON COLYLOPHORUM (Fischoeder, 1901).

Hosts.—Cattle and carabao (rumen).

Subfamily GASTROTHYLACINÆ Stiles and Goldberger, 1910

GASTROTHYLAX CRUMENIFER (Creplin, 1847).

Hosts.—Cattle and carabao (rumen).

CARMYERIUS GREGARIUS (Looss, 1896).

Hosts.—Cattle and carabao (rumen and reticulum).

FISCHOEDERIUS ELONGATUS (Poirier, 1883).

Hosts.—Cattle and carabao (rumen).

Subfamily GASTRODISCINÆ Monticelli, 1892

HOMALOGASTER PALONIAE Poirier, 1883.

Host.—Cattle (cæcum).

Subfamily DIPLODISCINÆ Cohn, 1904

DIPLODISCUS AMPHICHRUS sp. nov.

Hosts.—Frogs (small intestine and rectum).

Suborder DISTOMATA Zeder, 1800

Family FASCIOLIDÆ Railliet, 1895

Subfamily FASCIOLINÆ Stiles and Hassall, 1898

FASCIOLA HEPATICA (Linnæus, 1758).

Hosts.—Cattle, carabao, sheep, goat (bile ducts).

FASCIOLA GIGANTICA COBBOLD, 1856.

Hosts.—Cattle, carabao, sheep, goat (bile ducts).

Subfamily FASCIOLOPSINÆ Odhner, 1910

FASCIOLOPSIS BUSKI (Lankester, 1857).

Host.—Man (small intestine).

Reported by Schwartz (1924), who found the eggs of the parasite in the stools of several Chinese in the town of Jolo, Sulu Archipelago, P. I. It is not definitely known whether the infestation was contracted locally or in China.

Family ECHINOSTOMATIDÆ Looss, 1902

Subfamily ECHINOSTOMATINÆ Looss, 1899

ECHINOSTOMA REVOLUTUM (Froelich, 1802).

Host.—Domestic duck (cæcum) and domestic pigeon (small intestine).

ECHINOSTOMA CHLOROPODIS var. PHILIPPINENSIS Tubangui, 1932.

Host.—*Gallinula chloropus* (small intestine).

ECHINOSTOMA BATANGUENSIS Tubangui, 1932.

Host.—*Gallinula chloropus* (small intestine).

NEPHROSTOMUM BICOLANUM sp. nov.

Hosts.—*Herodias timoriensis* and *Bubulcus coromandus* (small intestine).

ECHINOPARYPHIUM RECURVATUM (v. Linstow, 1873).

Host.—Domestic duck (small intestine).

EUPARYPHIUM ILOCANUM (Garrison, 1908).

Hosts.—Man and *Mus norvegicus* (small intestine).

EUPARYPHIUM GUERREROI Tubangui, 1931.

Host.—*Mus norvegicus* (small intestine).

EUPARYPHIUM MURINUM Tubangui, 1931.

Host.—*Mus norvegicus* (small intestine).

Subfamily HIMASTHLINÆ Odhner, 1911

ACANTHOPARYPHIUM OCHTHODROMI sp. nov.

Host.—*Ochthodromus mongolus* (small intestine).

Subfamily ECHINOCHASMINÆ Odhner, 1911

ECHINOCHASMUS NOVALICHESENSIS Tubangui, 1932.

Host.—*Hypotænidia torquata* (small intestine).

Family PSILOSTOMIDÆ Odhner, 1913

PSILOCHASMUS LONGICIRRATUS Skrjabin, 1913.

Host.—Domestic duck (intestine).

Family AZYGIIDÆ Odhner, 1911

AZYGIA PRISTIPOMAI Tubangui, 1928.

Host.—*Pristipoma hasta* (intestine).

Family OPISTHORCHIIDÆ Luehe, 1901

Subfamily OPISTHORCHIINÆ Looss, 1899

OPISTHORCHIS WARDI Wharton, 1921.

Host.—Domestic cat (bile ducts).

Subfamily METORCHIINÆ Luehe, 1909

METORCHIS CAINTAENSIS Tubangui, 1928.

Host.—*Hypotænidia philippensis* (intestine).

Family TELORCHIIDÆ Stunkard, 1924

Subfamily TELORCHIINÆ Looss, 1899

CERCORCHIS CYCLEMIDIS sp. nov.

Host.—*Cyclemis amboinensis* (intestine).

Family CLINOSTOMIDÆ Luehe, 1901

CLINOSTOMUM DALAGI sp. nov.

Host.—*Ophiocephalus striatus* (encysted in eye sockets and pericardium).

CLINOSTOMUM PSEUDOHETEROSTOMUM sp. nov.

Host.—*Rana magna* (encysted between femoral muscles).

Family HARMOSTOMIDÆ Odhner, 1912

Subfamily HARMOSTOMINÆ Braun, 1900

HARMOSTOMUM sp. Tubangui, 1928.

Host.—*Dasylophus superciliosus* (rectum).

GLAPHYROSTOMUM RALLINARUM Tubangui, 1932.

Host.—*Rallina eurizonoides* (intestine).

LEUCOCHLORIDIUM DASYLOPHI Tubangui, 1928.

Host.—*Dasylophus superciliosus* (rectum).

LEUCOCHLORIDIUM HYPOTAENIDIARUM Tubangui, 1932.
Hosts.—Hypotaenidia striata and *Turnix fasciata* (intestine).

Family DICROCŒLIIDÆ Odhner, 1911

Subfamily DICROCŒLIINÆ Odhner, 1911

EURYTREMA OVIS Tubangui, 1925.
Hosts.—Sheep (fat surrounding rectum and pancreatic duct) and cattle (pancreatic duct).

PLATYNOSOMUM PHILIPPINORUM Tubangui, 1928.
Host.—Scutophilus temminckii (small intestine).

MESOCŒLIUM MEGGITTI Bhalerao, 1927.
Host.—Mabuya multifasciata (intestine).

PARADISTOMUM GREGARINUM Tubangui, 1929.
Synonym: *Paradistomum magnum* Tubangui, 1928.
Host.—Hemidactylus frenatus (gall bladder).

PARADISTOMUM PALOENSIS sp. nov.
Host.—Hydrosaurus pustulosus (gall bladder).

EUPARADISTOMUM VARANI Tubangui, 1931.
Host.—Varanus salvator (gall bladder).

Family BRACHYCŒLIIDÆ Johnston, 1912

Subfamily BRACHYCŒLIINÆ Looss, 1899

GLYPTHELMINS STAFFORDI Tubangui, 1928.
Host.—Rana vittigera (intestine).

Family LECITHODENDRIIDÆ Odhner, 1910

Subfamily LECITHODENDRIINÆ Looss, 1902

LECITHODENDRIUM OVIMAGNOSUM Bhalerao, 1926.
Host.—Scutophilus temminckii (intestine).

LECITHODENDRIUM LUZONICUM Tubangui, 1928.
Host.—Scutophilus temminckii (small intestine).

Subfamily PLEUROGENETINÆ Looss, 1899

PLEUROGENOIDES TAYLORI (Tubangui, 1928) Travassos, 1930.
Synonym: *Pleurogenes taylori* Tubangui, 1928.
Host.—Rana vittigera (intestine).

POSTORCHIGENES OVATUS Tubangui, 1928.
Host.—Hemidactylus frenatus (intestine).

Family STOMYLOTREMATIDÆ Poche, 1925

STOMYLOTREMA ROTUNDA Tubangui, 1928.
Host.—Hypotaenidia philippensis (intestine).

Family ALLOCREADIIDÆ (Stossich, 1904) Winfield, 1929

Subfamily ALLOCREADIINÆ Looss, 1902

ORIENTOCREADIUM BATRACHOIDES Tubangui, 1931.

Host.—*Clarias batrachus* (intestine).

Family PLAGIORCHIDÆ Luehe, 1901

STYPHLODORA RENALIS sp. nov.

Host.—*Python reticulatus* (kidney).

Family OPECŒLIDÆ (Ozaki, 1925) Ozaki, 1928

OPECOELUS MINIMUS Tubangui, 1928.

Hosts.—*Glossobius giurus*, *G. ocellatus* and *Pristipoma hasta* (intestine). This parasite is an intermediate form between the members of the genus *Opecœlus* Ozaki, 1925, in which the body is elongate and the vitellaria entirely postacetabular, and those of *Opegaster* Ozaki, 1928, in which the body is ovate and the vitellaria extending anteriorly beyond the acetabulum.

Family PHILOPHTHALMIDÆ Travassos, 1921

Subfamily PHILOPHTHALMINÆ Looss, 1899

PHILOPHTHALMUS PROBLEMATICUS Tubangui, 1932.

Host.—*Gallus gallus domesticus* (conjunctival sac).

PHILOPHTHALMUS RIZALENSIS Tubangui, 1932.

Host.—Domestic duck (conjunctival sac).

Family TROGLOTREMATIDÆ Odhner, 1914

PARAGONIMUS WESTERMANI (Kerbert, 1878).

Host.—Man, cat (lung).

Family HETEROPHYIDÆ Odhner, 1914

Subfamily HETEROPHYINÆ Ciurea, 1924

PHAGICOLA PITHECOPHAGICOLA Faust, 1920.

Host.—*Pithecophaga jefferyi* (intestine).

Faust (see Faust and Nishigori, 1926) after a restudy of his material renamed the parasite *Ascocotyle pithecophagicola.* Witenberg (1930), however, is of the opinion that it should be retained in the genus *Phagicola* Faust until the morphology of the worm is better known.

Subfamily HAPLORCHINÆ (Looss, 1899) Poche, 1926

HAPLORCHIS ANGUILLARUM sp. nov.

Host.—*Anguilla mauritiana* (intestine).

Subfamily CERCARIOIDINÆ Witenberg, 1929

SCAPHANOCEPHALUS ADAMSI sp. nov.

Host.—*Lepidaplois mesothorax* (encysted in fins and under scales).

SYSTEMATIC POSITION UNCERTAIN

METADENA MICROVATA Tubangui, 1928.

Hosts.—*Glossobius giurus*, *G. ocellatus*, *Pristipoma hasta* (intestine).

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ILLUSTRATIONS

[Drawn by A. Gonzales and V. V. Marasigan.]

PLATE 1

FIG. 1. *Diplodiscus amphichrus* sp. nov., young adult, ventral view.
2. *Diplodiscus amphichrus* sp. nov., fully mature specimen, ventral view.
3. *Austrobilharzia bayensis* sp. nov., lateral view.

PLATE 2

FIG. 1. *Nephrostomum bicolanum* sp. nov., head collar, ventral view.
2. *Nephrostomum bicolanum* sp. nov., entire worm, ventral view.
3. *Acanthoparyphium ochthodromi* sp. nov., collar, ventral view.
4. *Acanthoparyphium ochthodromi* sp. nov., entire worm, ventral view.

PLATE 3

FIG. 1. *Clinostomum pseudoheterostomum* sp. nov., ventral view.
2. *Cercorchis cyclemidis* sp. nov., ventral view.

PLATE 4

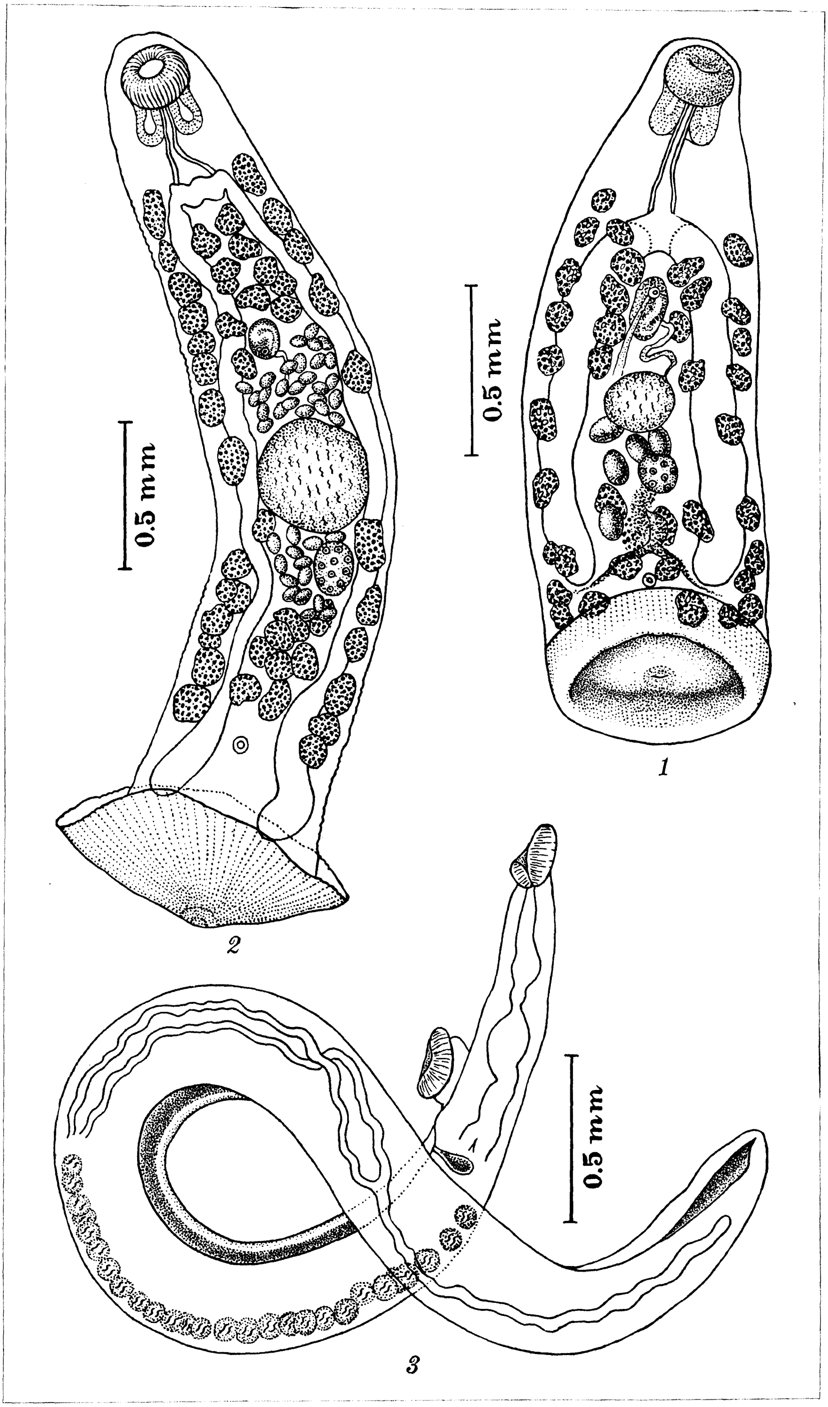
FIG. 1. *Clinostomum dalagi* sp. nov., ventral view.
2. *Paradistomum paloensis* sp. nov., ventral view.
3. *Haplorchis anguillarum* sp. nov., ventral view.
4. *Styphlodora renalis* sp. nov., ventral view.

PLATE 5

FIG. 1. *Tetracotyle bicolandiae* sp. nov., ventral view.
2. *Scaphanocephalus adamsi* sp. nov., ventral view.

PLATE 6

FIG. 1. *Neodiplostomum aluconis* sp. nov., ventral view.
2. *Apharyngostrigea garciai* sp. nov., ventral view.



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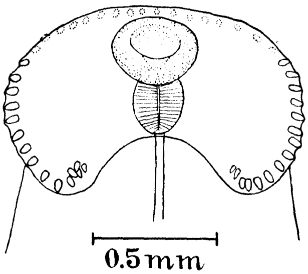

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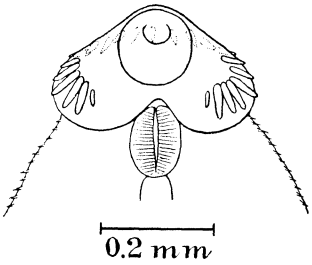

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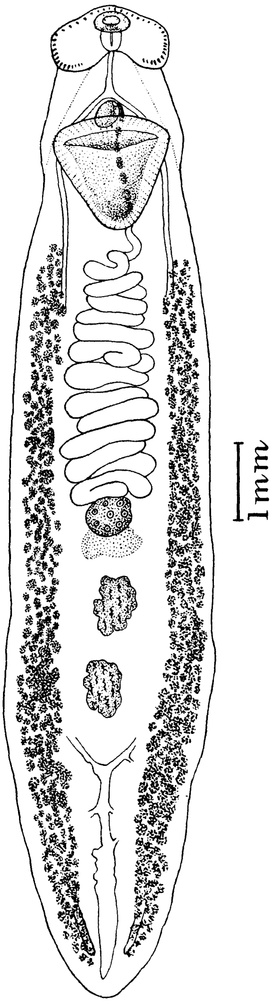

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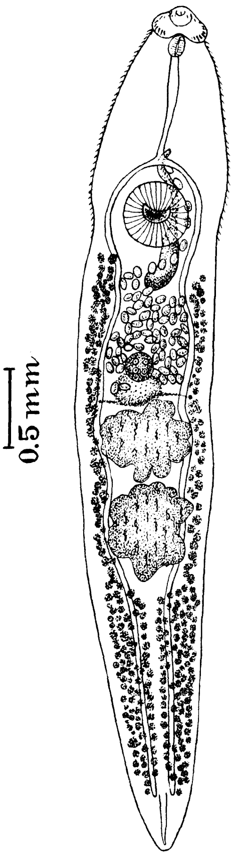

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PLATE 2.

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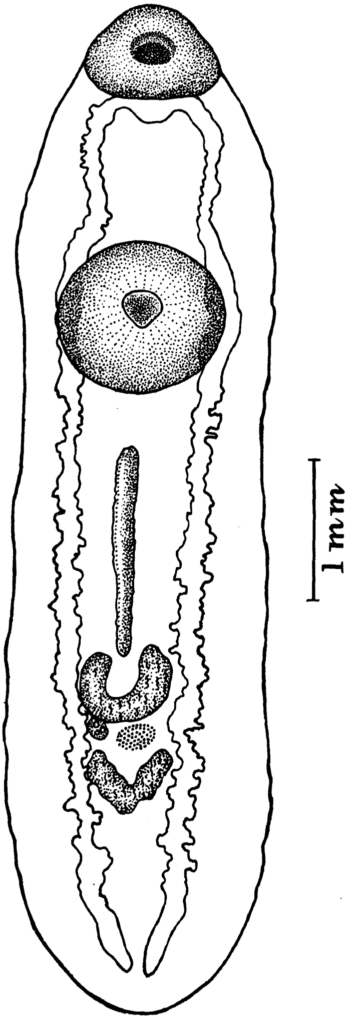

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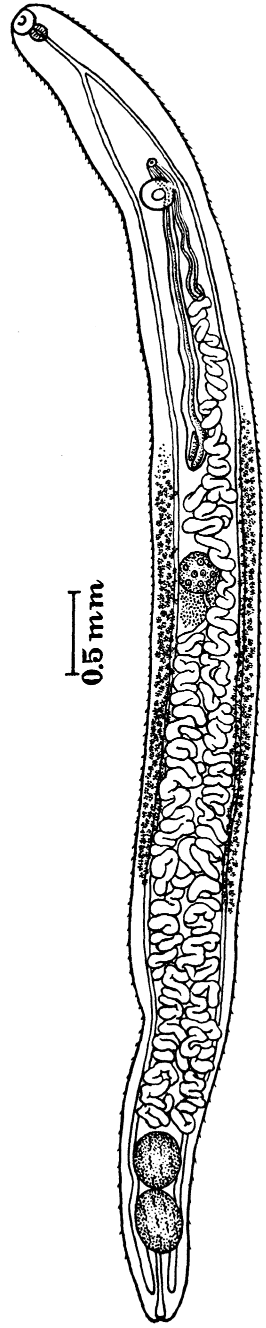

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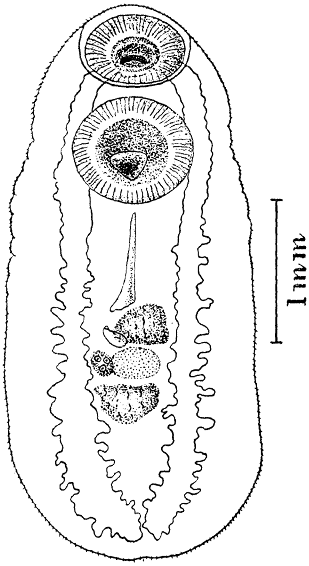
PLATE 3.



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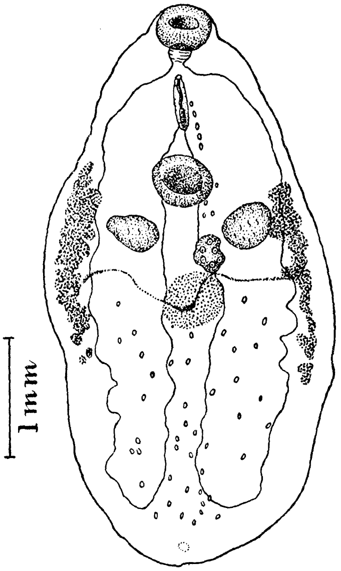

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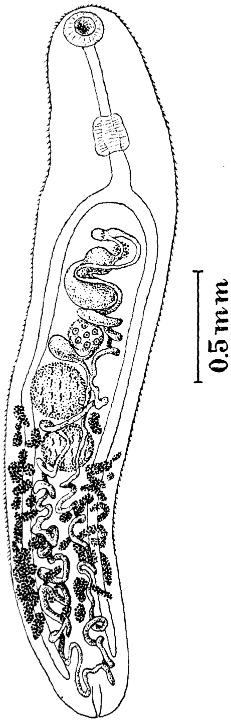

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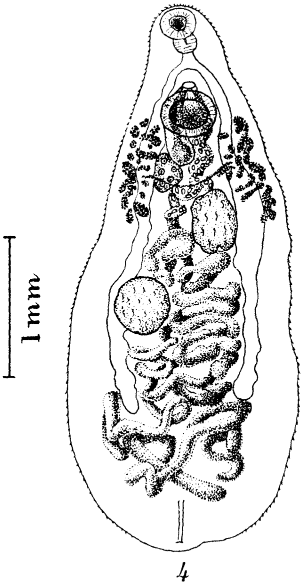

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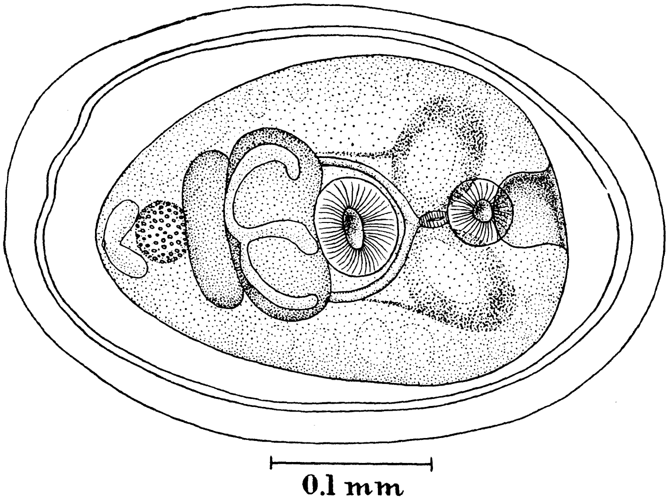
PLATE 4.



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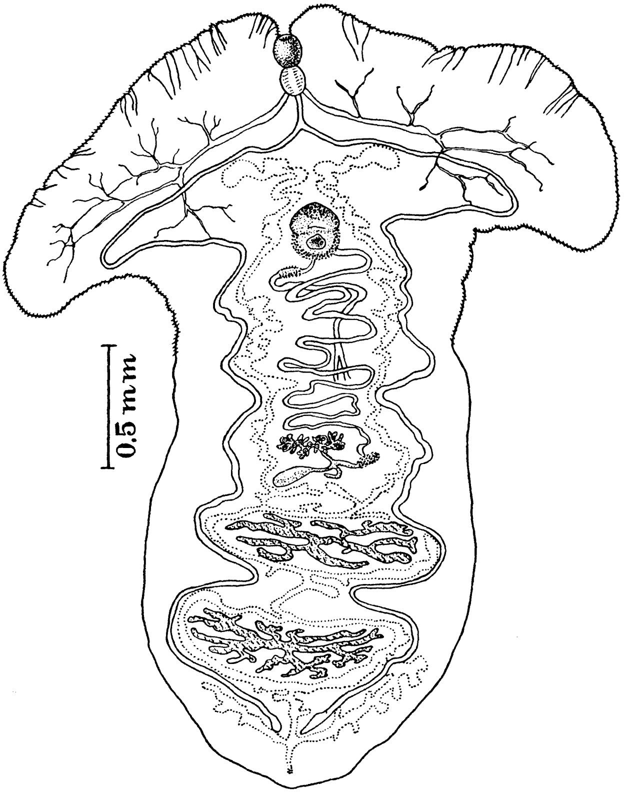

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PLATE 5.

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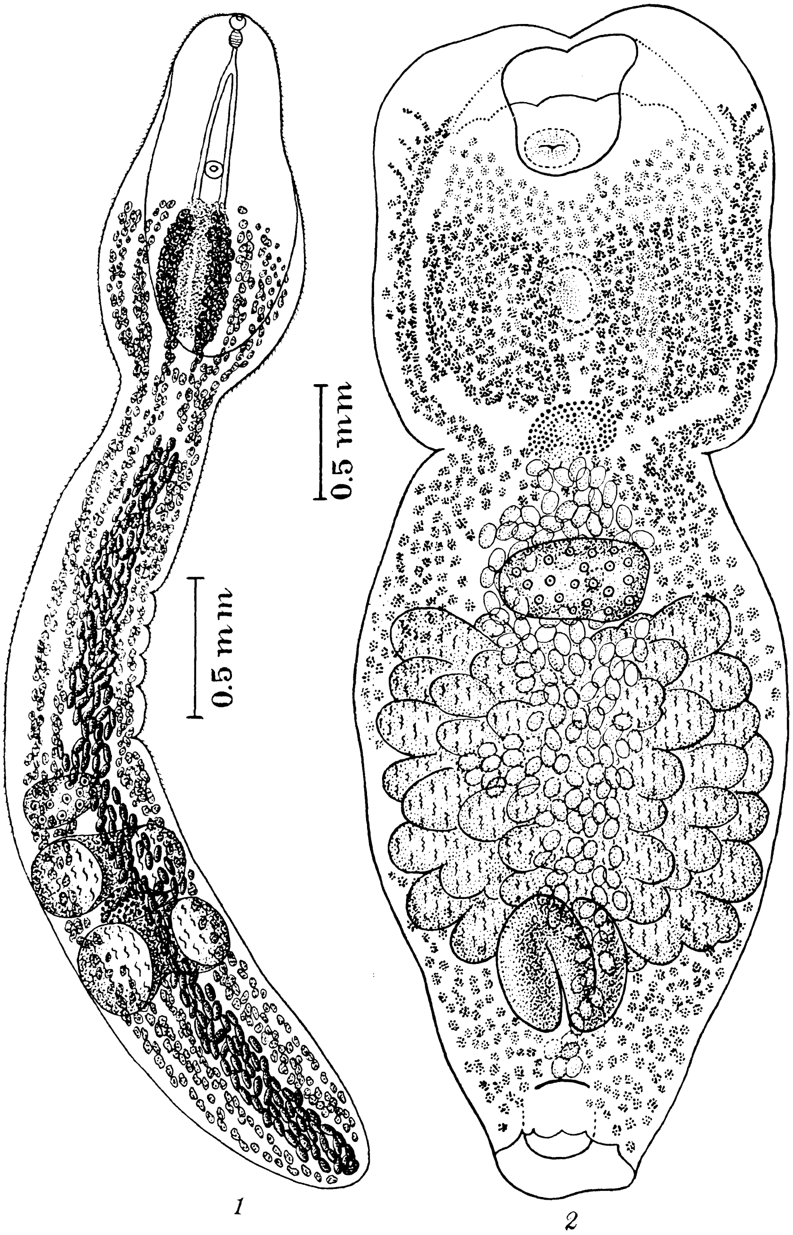


PLATE 6.

NEW SCOLYTIDÆ AND PLATYPODIDÆ FROM THE PHILIPPINE ISLANDS

By KARL E. SCHEDL

Naturhistorisches Museum, Vienna, Austria

A large amount of material, representing the families Scolytidæ and Platypodidæ, has been received from Mr. F. C. Hadden, Agricultural College, Laguna Province, Philippine Islands, and the following are some of the hitherto undescribed species; the remainder will be dealt with as soon as possible. For one species, *Ptilopodius stephegynis* Hopkins, a more-thorough description is given.

XYLEBORUS ARMILLATUS sp. nov.

Description of the female.—Yellowish brown, declivity darker, 2.71 millimeters long, pronotum 1.40 times as long as wide, elytra but little wider than the pronotum and 1.50 times as long as this.

Front subshining, convex, minutely punctulate, on the anterior half sparsely punctured and hairy.

Pronotum cylindrical, base truncate, acutely margined on the sides, posterolateral angles hardly rounded, sides subparallel on more than the basal half, broadly rounded in front; anterior margin unarmed, anterior third of the surface finely asperate, posteriorly rather coarsely but sparsely punctured. Pubescence consisting of long yellow hairs, denser on the sides and the anterior third.

Elytra cylindrical, brightly shining, base truncate, humeral angles feebly rounded, sides subparallel, broadly rounded behind, moderately deeply emarginate at the suture; disc striate-punctate, striæ not impressed, punctures rather remotely placed, interspaces flat, somewhat reticulate, with a few scattered punctures; declivity commencing in the apical third, deeply excavate, lateral margins strongly acute, with a blunt tooth on the summit of the second interspace, another rectangular tooth on the lateral margin in the middle of the declivity, and a third, the smallest, blunt tooth on the posterolateral edge of the excavation, between the teeth are several small setose tubercles;

excavation shining, finely sparsely punctured without indications of striæ. Sparse, long, yellow hairs on the sides, especially laterad on the declivity.

Holotype.—Female, Pangil, Laguna Province, Luzon, April 12, 1931 (*F. C. Hadden*).

This species is closely allied to *Xyleborus cylindromorphus* Eggers, but can easily be separated by the characters of the declivity.

XYLEBORUS LORICATUS sp. nov.

Description of the female.—Uniformly dark yellowish brown, 1.59 millimeters long, 3.27 times as long as wide, pronotum 1.22 times as long as wide, elytra at the base as wide and 1.61 times as long as the pronotum.

Front convex, shining, minutely punctulate, with a few coarse punctures near the epistomal margin.

Pronotum cylindrical, base truncate, posterolateral angles strongly rounded, sides subparallel on more than the basal half, feebly constricted before the middle, broadly rounded in front; anterior margin hardly noticeably crenate, anterior area feebly asperate, with sparse long hairs, posterior area shining, nearly impunctate but minutely reticulate; sides acute but not margined. Scutellum triangular, smooth shining.

Elytra cylindrical, humeral angles rectangular, sides parallel, angulately rounded behind, with a triangular emargination at the suture so that each elytron appears accuminate at the apex; disc shining, rather feebly striate-punctate, striæ not at all impressed, interspaces subrugulose with fine scattered punctures; declivity commencing at the posterior third, convex, acutely margined below, somewhat depressed near the side margins, dull, strial punctures stronger, shining, interspaces densely rugose giving a rough opaque appearance.

Holotype.—One female, Mount Maquiling, Laguna Province, Luzon, November 1, 1933 (*F. C. Hadden*).

A peculiar species, which is distinct from any known form.

XYLEBORUS PERMARGINATUS sp. nov.

Description of the female.—Dark brown, declivity blackish, 5.87 millimeters long, 2.09 times as long as wide, with rather dense, long, erect pubescence.

Front convex, median line slightly elevated and polished, finely roughly punctured above the epistomal margin, transversely elevated between the eyes, elevation centrally nearly devoid of punctures, finely, rugosely punctured along the cephalic margin of the eyes; transversely impressed above, with deep rather coarse punctures which are densely placed.

Pronotum globose, 1.36 times as wide as long, base truncate, posterolateral angles rectangular, sides parallel on the posterior third, uniformly rounded in front; anterior margin armed with a triangular plate consisting of the fused median teeth, anterior area steep, summit behind the middle, the entire surface asperate, denser and coarser anteriorly, more remotely placed and finer behind. Scutellum small, cordiform, shining.

Elytra as wide and 1.64 times as long as the pronotum, cylindrical, sides subparallel, slightly dilated towards the declivity, broadly rounded behind; disc shining, with a feeble transverse impression before the declivity, densely coarsely punctured, the striæ obsolete near the base, more distinct towards the declivity where they become also feebly impressed; declivity commencing shortly behind the middle, obliquely truncated, with an elevated, well-defined, crenulate margin all around, declivous face slightly covex, suture somewhat depressed, first interstice with a row of punctures, second slightly elevated, widened, densely punctured and with a few small tubercles at the center, other striæ feebly but distinctly impressed, interspaces densely roughly punctured.

Holotype.—Female, Mount Maquiling, Laguna Province, Luzon, August 16, 1931 (*F. C. Hadden*).

Paratypes.—Two females, same data.

This species was kindly compared with other material by Mr. Hans Eggers. It is identical with his *X. permarginatus* in lit., and his name has been adopted.

Xyleborus desectus Eggers, which is closely allied to my species, is smaller, the elytra are slenderer, and the declivital margin is much lower.

PTILOPODIUS STEPHEGYNIS Hopkins.

Description of the adult beetle.—Pronotum dark brown, elytra reddish brown, 1.19 millimeters long, exactly twice as long as wide.

Front plano-convex, minutely and very densely punctured, with a low longitudinal carina extending from the epistomal margin to the vertex, at first inconspicuous, shortly above the epistomal margin interrupted by a small patch of very coarse punctures which are situated on and at the sides of the frontal suture, above broad, distinctly elevated; anterior area with medium long scattered hairs. Eyes oblong, not emarginate in front; antennæ with the club oval, 1.36 times as long as broad, without septa or sutures, anterior face moderately densely covered with short filiform setæ, posterior face with a few scattered setæ only, funicle four-jointed, joint four scarsely broader than the second.

Pronotum subopaque, slightly broader than long (20.5:18.5), widest near the base, posterior line distinctly produced medially, posterolateral angles slightly rounded, rather uniformly rounded at the sides, constricted before the middle, anterior margin narrowly rounded; summit behind the middle, anterior area steep and covered with remotely placed rather small asperities, anterior margin with fine asperities of nearly equal size, posterior area depressed and finely reticulate; side margins acute. Scutellum rectangular, subopaque.

Elytra wider and 1.40 times as long as the pronotum, sides subparallel on the anterior three-fifths, broadly rounded behind, declivity convex, striæ distinct but not impressed, strial punctures moderately large, rather shallow, not densely placed, interspaces finely reticulate, uniseriately finely punctured, from the punctures arise erect scalelike hairs which become more like true scales on the declivity.

Anterior tibiæ and tarsal segments with plumed appendages.

The large series I have came from Mount Maquiling, Laguna Province, Luzon, and was collected by Mr. F. C. Hadden.

PLATYPUS CIRCULARIS Chappuis fem. nov.

Yellowish brown, head, pronotum, and declivity nearly black, 2.85 millimeters long, 4.3 times as long as wide.

Front flat, shining, very coarsely and rather sparsely punctured below, finer and denser above, vertex with the median line and another line laterad to that elevated and polished, remaining surface finely rugosely punctured.

Pronotum 1.6 times as long as wide, widest behind the lateral emargination, strongly shining, median sulcus fine, longer than the basal two-thirds of the pronotum, with a narrow deep patch of punctures of uniform size around the sulcus; remaining surface sparsely but rather coarsely punctured, a space laterad of the sulcus nearly devoid of punctures, the punctures more crowded near the base.

Elytra 1.7 times as long as the pronotum, as wide at the base and distinctly wider than the pronotum before the truncated apex; striæ punctate, sutural striæ and the eighth deeply, others not at all impressed, interspaces flat subimpunctate, base of the third with a few obscure punctures; on the apical fourth the strial punctures at first coarse, densely placed, striæ impressed and interstices convex, then becoming more and more densely punctate; the apex perpendicular, finely rugosely punctured, with two shallow emarginations forming two blunt prolongations at each side similar to those in the male. Pubescence on the slope and truncation short and sparse.

Allotype.—Female, Mount Maquiling, Laguna Province, Luzon, April 11, 1931 (*F. C. Hadden*), from a log of balobo, *Diplodiscus paniculatus* Turcz.

TWO INTERESTING SHELLS FROM THE PHILIPPINE ISLANDS

By IDA S. OLDROYD

Curator of the Geological Museum, Leland Stanford Junior University California

ONE PLATE

The two species of shells described below were from the collection of the late Mrs. S. A. Mitchell, who was a resident of Manila for many years and who had a large collection of Philippine shells from various parts of the Archipelago. A portion of this collection was donated to Leland Stanford Junior University by her daughter, Mrs. S. L. Burkholder, of Manila. In working over this collection to send the duplicates to the Bureau of Science, Manila, in accordance with the request of Mrs. Burkholder, I came across many interesting shells:

ACMAEA STRIATA MITCHELLI subsp. nov. Plate 1, figs. 1 to 4.

Shell orbicular, striated, black and white on the outside and blue-white on the interior, with a central brownish spot, which in some specimens is dark, in others very light. The margin is black except at the places where the white wedge-shaped color patches, which number two or four, run from the interior central spot to the margin; on the exterior the white color wedges approach the apex more closely. Length, 28 millimeters; breadth, 25.

Type.—No. 16369, Bureau of Science, collected by Mrs. S. A. Mitchell.

Paratypes.—Conchological collection, Leland Stanford Junior University.

Type locality.—Southern Luzon, Philippine Islands.

This subspecies differs from *Acmaea striata* in having the white wedge-shaped color bands.

NERITA MITCHELLI sp. nov. Plate 1, figs. 5 to 7.

Shell thick, with fifteen to eighteen fine spiral riblets, the interstices of equal width. Exterior dirty white, banded with dull rose; in some cases the color nearly covers the shell while in others only part of the body whorl is rose. Aperture porcellaneous and polished, outer lip thickened with faint dentations within. Columellar lip with from three to four dentations, the type having three; the columellar area with fine ridges covering the entire area and highly polished.

Type.—No. 16368, Bureau of Science, collected by Mrs. S. A. Mitchell.

Paratype.—Conchological collection, Leland Stanford Junior University.

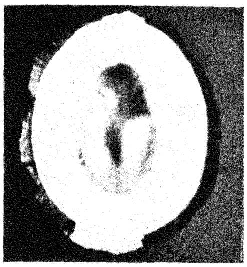
Locality.—Philippine Islands, no definite locality label.

This species belongs to the *Nerita polita* group, and differs from that species in that the spire is much higher and the sutures deeper. It is named for the collector, Mrs. S. A. Mitchell.

ILLUSTRATION

PLATE 1

FIGS. 1 to 4. *Acmaea striata mitchelli* subsp. nov.
5 to 7. *Nerita mitchelli* sp. nov.



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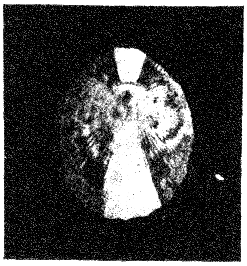

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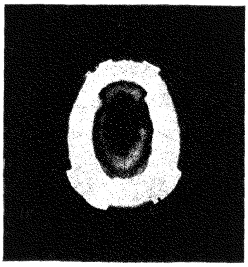

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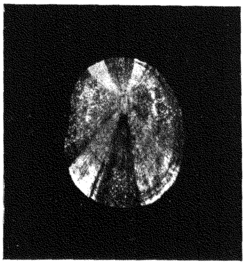

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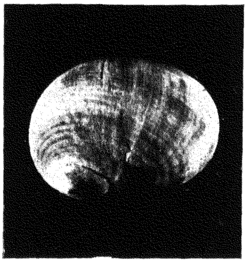

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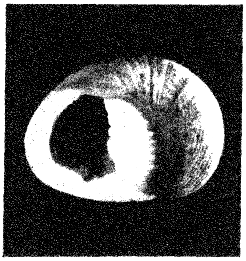

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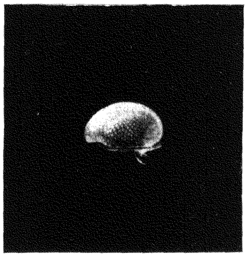

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PLATE 1.

THE COMPOSITION OF SOME PHILIPPINE SOFT WOODS, V[1]

By AUGUSTUS P. WEST, F. M. YENKO, and LUZ BAENS
Of the Bureau of Science, Manila
and
H. M. CURRAN
Of the Bureau of Forestry, Manila

FIVE PLATES

The composition of woods is a matter of considerable importance for industries which use wood as their basic raw material. This paper is a continuation of our work on the composition of Philippine woods. Four papers have already appeared[2] and this one makes our fifth report.

An account of the general properties of some of these woods is given by Schneider.[3] Data on the woods which are not recorded by Schneider have been furnished us by Mr. M. D. Sulit, of the Bureau of Forestry. Brief descriptions are as follows:

Anabiong [*Trema orientalis* (Linn.) Blume] is a medium-sized tree reaching a diameter of 30 to 40 centimeters. The trunk (bole) is generally crooked and short, but when the tree is in a thick pure stand the trunk is straight. The bark is smooth and thick. The presence of lichens gives the bark a rather white appearance. The bark contains a watery liquid which has a color ranging from brown to blue and, when cut, stains the bolo. The crown of the tree is wide and spreading.

Anabiong is found throughout the Philippines at low and medium altitudes. It is characteristic of deserted clearings and second-growth vegetation where it occurs abundantly in pure stands. In Batangas Province the bark is used for dyeing clothes and fish nets. The leaves are used for fodder and are gathered extensively during the dry season. The wood of anabiong is soft.

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[1] This work is carried on coöperatively by the division of chemical research, Bureau of Science, and the Bureau of Forestry.

[2] Yenko, F. M., Luz Baens, A. P. West, and H. M. Curran, Philip. Journ. Sci. 47 (1932) 281 and 343; 48 (1932) 299; 49 (1932) 587.

[3] Bull. P. I. Bur. Forestry 14 (1916).

Fire (flame) tree [*Delonix regia* (Boj.) Saf.] is a medium-sized tree which is planted considerably in the Islands. The trunk is irregular and buttressed low. The diameter usually ranges from 30 to 40 centimeters. Trees planted in the open on good soil reach much larger diameters. The fire tree has a low, wide-spreading crown. It is deciduous (not evergreen) and has an average height of 12 to 15 meters. The showy scarlet flowers usually appear before the leaves. When in bloom this species is, perhaps, the most beautiful tree in the Islands.

The wood is soft in young trees and suitable for wooden shoes. It is not durable in the ground and is readily destroyed by termites.

Palong-manok [*Alangium chinense* (Lour.) Rehder] is a small to medium-sized, deciduous tree which is common in second-growth forests. The young tree has a smooth round trunk with a rather white bark. Palong-manok grows to a height of 15 meters, and the diameter ranges from 20 to 30 centimeters. The wood is not durable and of little commercial value. The sapwood is light colored and the heartwood dark. This tree is usually found from Ilocos Norte to Rizal, Laguna, and Batangas Provinces in primary and secondary forests at low altitudes.

Balsa (*Ochroma lagopus* Schwartz) is an upright branching tree which sometimes attains a diameter of about 60 centimeters and a height of about 18 to 21 meters. This tree has an open crown and a rather white bark.

In the Philippines there are promising prospects for the growing of balsa wood as a plantation crop. It is one of the lightest and fastest growing trees in the world. Trees planted in the Bureau of Forestry plantation at Los Baños showed after eight years an average yearly growth of about 4.5 centimeters in diameter and 2.2 meters in height. The young and fast-growing trees have the lightest wood. The maximum height may be attained in about ten years, but at this age the wood is of little value as it is not so porous and light. The wood near the pith, or center, is lighter than that near the bark. Although it is strong for its weight balsa wood crushes easily. If exposed, it is likely to be discolored, or attacked by borers and decay.

The balsa tree is propagated easily by seed and begins to bear fruit after three or four years. The pods contain fine fibers which have a silky appearance. These fibers in which the seeds are embedded have no value for textile purposes but are useful for making mattresses, pillows, and cushions.

Balsa wood is useful for various purposes. On account of its lightness and buoyancy it is especially suitable for use in the manufacture of rafts, life boats, life preservers, and aëroplanes. It has been employed in the manufacture of insulation products and refrigerators. As it has natural acoustic or tonal properties it has been found to be satisfactory for use in the manufacture of radio loud speakers.

Ilang-ilang [*Canangium odoratum* (Lam.) Baill.] is a medium-sized tree which may reach a diameter of 50 to 60 centimeters. The trunk, which is sometimes fluted, is usually straight and characterized by a light gray color. The bark is thick and fibrous. Ilang-ilang is cultivated throughout the Islands. It is also found in primary and second-growth forests at low and medium altitudes.

Ilang-ilang oil is obtained by steam-distilling the flowers of this species. This essential oil, in perfume literature, is sometimes called the "flower of flowers." It is used considerably in the perfumery industry in the preparation of high-grade perfumes, such as lily of the valley and corylopsis. The manufacture of ilang-ilang oil is practically the only perfume industry in the Philippines.[4]

A good description of the distillation of ilang-ilang oil is given by Bacon [5] who worked out the process.

Alim [*Melanolepis multiglandulosa* (Reinw.) Reichb. f. and Zoll.] is a small to medium-sized tree which has an average diameter of 20 to 30 centimeters. It is seldom found in the forest but usually in open and abandoned places. This tree has a straight, short trunk with an open crown. The bark is finely ridged and has a color which varies from white to yellow. Alim is found throughout the Islands at low and medium altitudes.

Aleurites.—Two species of the genus *Aleurites* are found in the Philippines—*Aleurites trisperma* (baguilumbang) and *Aleurites moluccana* (lumbang). The wood of these species is practically identical. It is light, soft, and has a rather white color. The grain is straight, the texture rather coarse, and the durability poor. There is no distinct difference between the sapwood and heartwood. The wood is used for making matches, wooden shoes, and floats for fish nets.

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[4] West, A. P., and W. H. Brown, Philip. Bur. Forestry, Bull. 20 (1920).

[5] Philip. Journ. Sci. § A 3 (1908) 65; § A 4 (1909) 127; § A 5 (1910) 265.

Baguilumbang (*Aleurites trisperma* Blanco) is a medium-sized forest tree which reaches a diameter of 15 to 20 centimeters or more. The trunk is straight, cylindrical, and without a prominent buttress. The bark varies in color from brown to rather white and has a creamy appearance when cut.

Baguilumbang grows in forests at low and medium altitudes from northern Luzon to Mindanao. It seems to grow best near river banks or in valleys where it is protected from strong winds or typhoons. Baguilumbang oil obtained from the seeds of this species is not edible or suitable for use as a drying oil.

Lumbang (*Aleurites moluccana* Willd.) is a tree which grows to a diameter of 150 centimeters with a short but regular bole. It is distributed from Luzon to Mindanao and Palawan. The wood is practically identical with that of baguilumbang and is suitable for the same purposes for which baguilumbang is used. The Hawaiians used to string the seeds of the lumbang tree on sticks and use them as candles to light their houses. The name "candle nut" originated from this use of the lumbang nuts and hence this tree was called the candle-nut tree.

Philippine lumbang (candle-nut) oil is obtained from the seeds of *Aleurites moluccana.* Lumbang oil is a drying oil which is used in making paints, varnishes, and similar products.[6] It has a composition similar to linseed oil and consists principally of the glycerides of linolenic, linolic, and oleic acids.[7] Philippine lumbang oil and the compounds contained in it have been investigated extensively.[8]

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[6] West, A. P., and W. H. Brown, Bull. P. I. Bur. Forestry 20 (1920) 121.

West, A. P., and F. L. Smith, Bull. P. I. Bur. Forestry 24 (1923).

[7] West, A. P., and Z. Montes, Philip. Journ. Sci. 18 (1921) 619.

Cruz, A. O., and A. P. West, Philip. Journ. Sci. 42 (1930) 251.

[8] West, A. P., and L. Gonzaga, Philip. Journ. Sci. 23 (1923) 277.

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Jovellanos, C. M., and A. P. West, Philip. Journ. Sci. 33 (1927) 349.

Santos, I., and A. P. West, Philip. Journ. Sci. 34 (1927) 199.

Vicente, M. L. A., and A. P. West, Philip. Journ. Sci. 36 (1928) 73.

Malapapaya [*Polyscias nodosa* (Blm.) Seem.] is a medium-sized tree which reaches a diameter of 40 to 50 centimeters. It is conspicuous for its characteristic growth habit. The trunk is straight with considerable tapering, and the tree, even when mature, has very few branches. The bark is rather white with prominent leaf scars. The wood is soft and light and the color varies from white to cream.

This species is found throughout the Islands at low and medium altitudes in second-growth forests and abandoned clearings.

Rain tree [*Samanea saman* (Jacq.) Merr.] is a large tree which may attain a diameter of 100 centimeters or more and a height of 20 to 25 meters. The bark is ridged and the branches wide-spreading and drooping. The wood, like akle, is suitable for making furniture but is seldom used. This species is commonly cultivated as a shade tree in towns located at a low altitude.

Basikong (*Ficus conora* King) is a small to medium-sized forest tree which reaches a diameter of 20 to 30 centimeters. The trunk is usually crooked and short. This species is characterized by tubercles (about 30 to 50 centimeters long) which are found on the branches and where the fruits (figs) grow. The bark has a dark-gray color with white spots which are caused by lichens. The wood is soft to medium with a white or gray color. This species has a wide-spreading and dense crown and grows at low and medium altitudes.

Tibig [*Ficus nota* (Blanco) Merr.] is a medium-sized tree which reaches a diameter of 20 to 30 centimeters. The trunk, which is short and generally crooked, is characterized by cauliflower tubercles. This species has an open crown and few branches. It grows throughout the Islands in thickets and forests at low medium altitudes and is very common along creeks. The wood is light and soft and has a white or gray color.

Binuñga [*Macaranga tanarius* (Linn.) Muell.-Arg.] is a small to medium-sized tree which is characteristic of deserted clearings and parang vegetation. The trunk is short and crooked and usually attains a diameter of 15 to 25 centimeters. This tree has an open and spreading crown. The bark is rather white but appears red when cut. The wood is light, soft, and white. This species is found throughout the Islands at low and medium altitudes.

Gubas (*Endospermum peltatum* Merr.) is a large forest tree which attains a diameter of 70 to 80 centimeters. The trunk is straight and without a prominent buttress. The color of the bark ranges from white to yellow and, when cut, the inner bark has a golden yellow color and a disagreeable odor. The wood is soft and pale yellow. This species is found throughout the Islands in primary forests at low altitudes.

TABLE 1.—*Measurements of Philippine trees used for wood analysis.*

Name of tree.	Diameter.	Total height.	Clear length of trunk.	Height from which specimen was taken.	Specific gravity of wood.[a]
	cm.	*m.*	*m.*	*m.*	
Anabiong; *Trema orientalis*	20	10.5	5.35	2.5	0.407
Fire tree; *Delonix regia*	16.5	17.0	5.3	3.10	0.411
Palong-manok; *Alangium chinense*	24.4	15.0	11.6	0.9	0.682
Balsa; *Ochroma lagopus*	17.6	12.0	5.05	3.6	0.138
Ilang-ilang; *Canangium odoratum*	21.0	13.4	11.0	0.7	----------
Alim; *Melanolepis multiglandulosa*	14.8	13.6	6.4	1.65	0.413
Baguilumbang; *Aleurites trisperma*	21.7	7.9	6.7	0.25	0.408
Lumbang; *Aleurites moluccana*	17.0	14.6	8.2	2.9	0.366
Malapapaya; *Polyscias nodosa*	19.1	12.8	12.0	0.60	0.496
Rain tree; *Samanea saman*	24.8	16.5	4.8	4.8	0.559
Basikong; *Ficus conora*	29.0	9.0	3.5	0.50	0.560
Tibig; *Ficus nota*	26.0	9.0	4.2	0.45	0.518
Binuñga; *Macaranga tanarius*	10.6	11.6	5.0	1.3	0.456
Gubas; *Endospermum peltatum*	17.3	12.0	7.0	1.4	0.456

[a] Figures for specific gravity are only approximate as the wood of some trees varies considerably.

In Table 1 are given the measurements of the trees from which samples were taken for our analyses.

In analyzing the wood samples we followed, in general, the methods adopted by the forest products laboratory at Madison, Wisconsin.[9] Certain details,[10] which we had found by previous experience to increase the accuracy of the results, were introduced in the analytical procedures.

[9] Bray, M. W., Paper Trade Journ. 87 No. 25 (1928) 59.
Schorger, A. W., Chemistry of Cellulose and Wood (1926) 505.

[10] Yenko, F. M., Luz Baens, A. P. West, and H. M. Curran, Philip. Journ. Sci. 47 (1932) 343.

RESULTS

The results obtained by analyzing the woods recorded in this paper are given in Table 2.

TABLE 2.—*Analysis of Philippine softwoods.*

Constituent.	Anabiong: *Trema orientalis.*	Fire tree: *Delonix regia.*	Palong-manok: *Alangium chinense.*	Balsa: *Ochroma lagopus.*	Ilang-ilang: *Canangium odoratum.*	Alim: *Melanolepis multiglandulosa.*	Baguilumbang: *Aleurites trisperma.*
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent*	*Per cent.*	*Per cent.*
Cold-water soluble	3.43	4.55	7.50	1.99	4.66	6.50	3.33
Hot-water soluble	6.63	8.37	13.39	3.99	10.18	12.82	6.49
Alkali soluble	20.56	17.25	23.00	21.62	15.97	25.30	22.39
Ether extract	0.44	0.22	0.84	1.16	0.97	0.45	0.56
Alcohol extract	4.43	3.60	10.25	2.74	3.38	2.09	2.42
Ash	1.16	1.77	0.84	0.85	2.51	1.32	1.74
Nitrogen	0.35	0.38	0.37	0.49	0.43	0.44	0.35
Lignin	28.72	24.65	29.33	28.83	23.38	29.07	31.71
Cellulose	55.02	58.66	51.47	54.68	45.91	50.97	51.10
Ash in cellulose determined	0.31	0.30	0.26	0.47	0.33	0.39	0.57
Cellulose ash free	54.71	58.36	51.21	54.21	45.58	50.58	50.53
Alpha cellulose in total cellulose	75.36	78.12	81.00	74.05	80.28	75.23	74.00
Alpha cellulose in the wood	41.46	45.83	41.69	40.49	36.86	38.34	37.81

Constituent.	Lumbang: *Aleurites moluccana.*	Malapapaya: *Polyscias nodosa.*	Rain tree: *Samanea saman.*	Basikong: *Ficus conora.*	Tibig: *Ficus nota.*	Binuñga: *Macaranga tanarius.*	Gubas: *Endospermum peltatum.*
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Cold-water soluble	5.05	2.60	3.47	4.84	5.48	3.39	2.69
Hot-water soluble	9.64	10.20	8.86	8.84	8.36	6.27	7.84
Alkali soluble	21.26	24.72	19.89	17.66	18.39	14.66	17.86
Ether extract	0.06	0.88	0.87	0.13	0.54	0.22	0.44
Alcohol extract	1.48	5.08	5.34	2.92	3.23	2.60	3.14
Ash	2.14	0.90	0.27	2.63	3.95	0.93	0.79
Nitrogen	0.36	0.30	0.58	0.34	0.49	0.40	0.40
Lignin	20.13	30.30	30.44	33.86	33.67	32.06	30.83
Cellulose	59.59	49.53	50.89	47.28	45.17	50.02	54.64
Ash in cellulose determined	0.97	0.42	0.41	0.18	0.63	0.38	0.27
Cellulose ash free	58.62	49.11	50.48	47.10	44.54	49.64	54.37
Alpha cellulose in total cellulose	77.93	73.33	75.35	73.62	73.49	79.51	80.96
Alpha cellulose in the wood	46.44	36.32	38.35	34.81	33.20	39.77	44.24

SUMMARY

Fourteen samples of wood from Philippine softwood trees were analyzed in this investigation. These woods have the common names anabiong, fire tree, palong-manok, balsa, ilang-ilang, alim, baguilumbang, lumbang, malapapaya, rain tree, basikong, tibig, binuñga, and gubas.

As shown by the data (Table 2) the lumbang wood has the highest content of cellulose and alpha cellulose but the lowest lignin content. Basikong has the highest lignin content. Tibig has the highest ash but the lowest cellulose and alpha cellulose content. The rain tree has the lowest ash content.

ILLUSTRATIONS

PLATE 1

FIG. 1. Fire tree; *Delonix regia* (Boj.) Raf.
2. Anabiong; *Trema orientalis* (Linn.) Blume.

PLATE 2

FIG. 1. Palong-manok; *Alangium chinense* (Lour.) Rehder.
2. Balsa; *Ochroma lagopus* Schwartz.
3. Ilang-ilang; *Canangium odoratum* (Lam.) Baill.

PLATE 3

FIG. 1. Alim; *Melanolepis multiglandulosa* (Reinw.) Reichb. f. and Zoll.
2. Baguilumbang; *Aleurites trisperma* Blanco.
3. Lumbang; *Aleurites moluccana* Willd.

PLATE 4

FIG. 1. Malapapaya; *Polyscias nodosa* (Blm.) Seem.
2. Rain tree; *Samanea saman* (Jacq.) Merr.
3. Basikong; *Ficus conora* King.

PLATE 5

FIG. 1. Tibig; *Ficus nota* (Blco.) Merr.
2. Binuñga; *Macaranga tanarius* (Linn.) Muell.-Arg.
3. Gubas; *Endospermum peltatum* Merr.

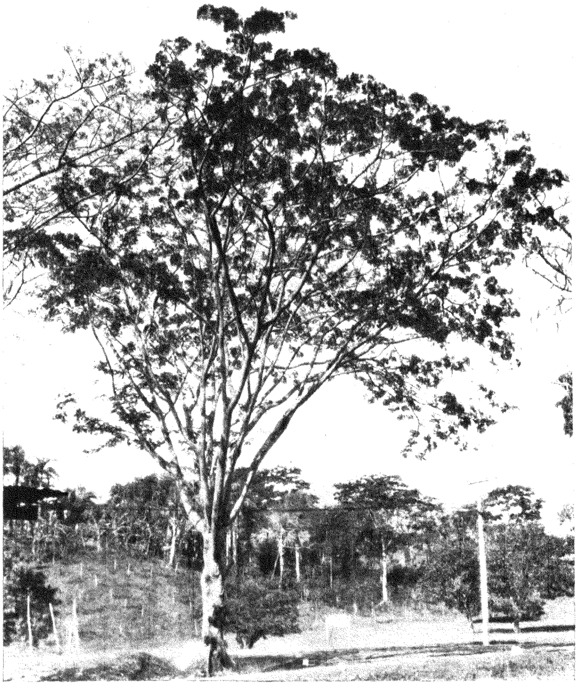

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PLATE 2.

PLATE 3.

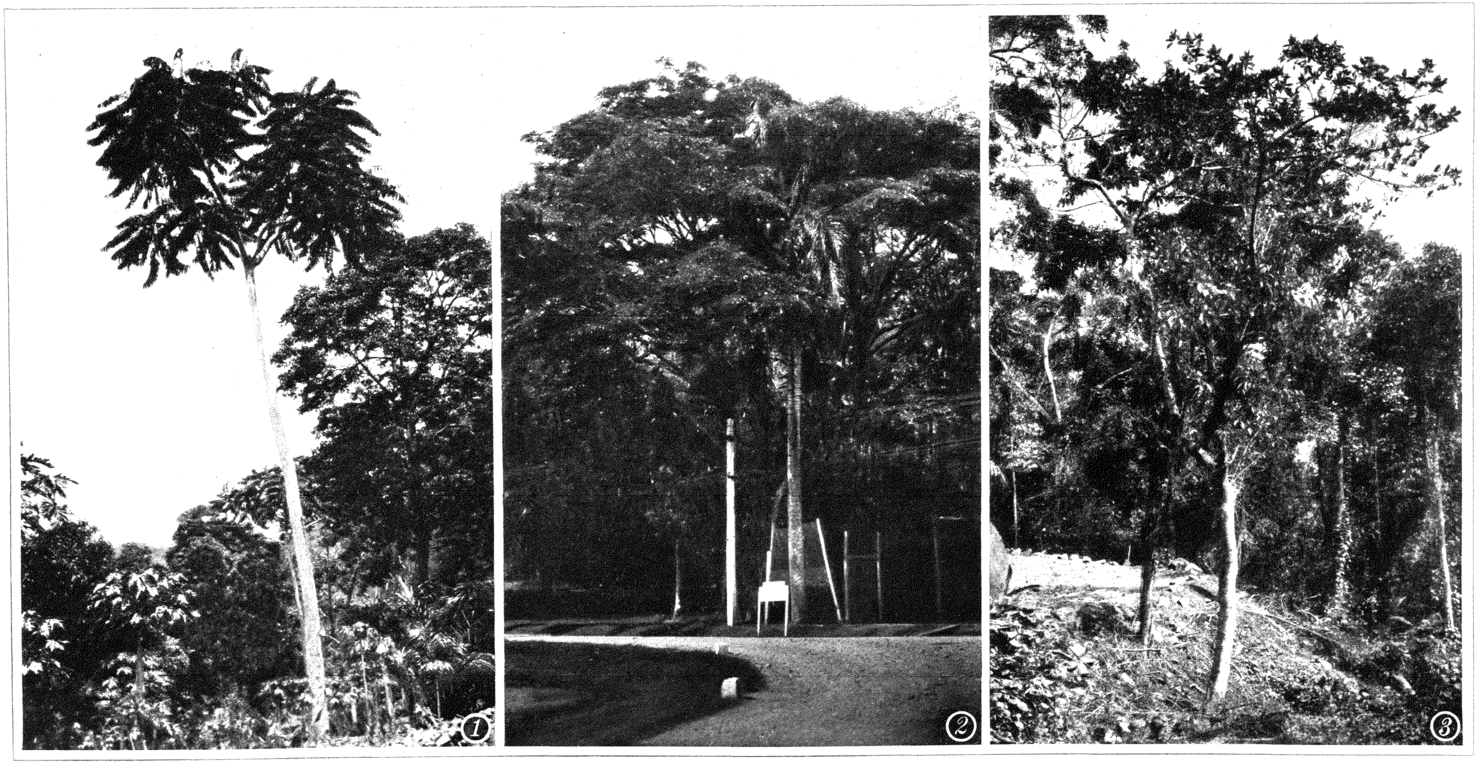

PLATE 4.

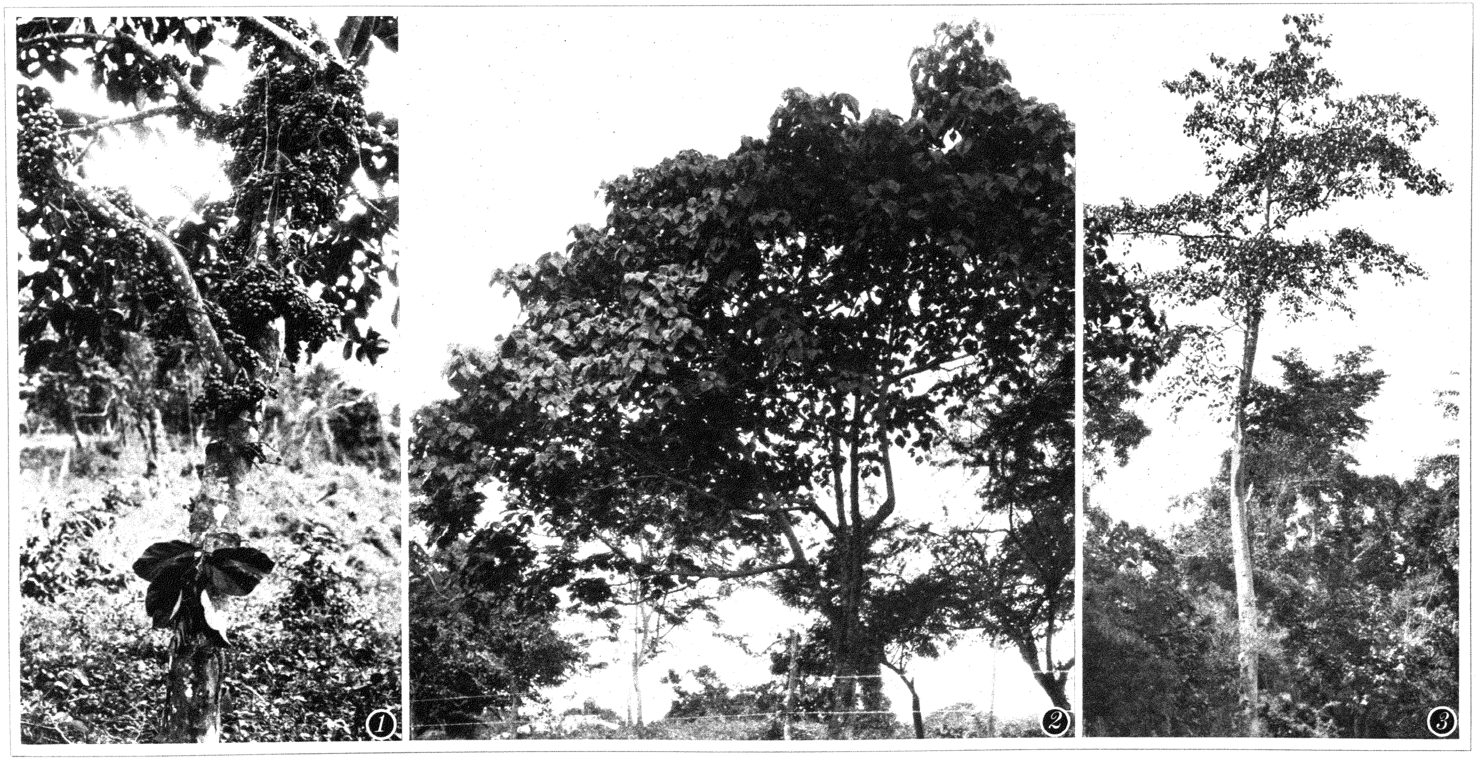

PLATE 5.

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BACTERIOLOGICAL, CHEMICAL, AND BIOLOGICAL STUDIES OF RECONSTITUTED MILK

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THREE TEXT FIGURES

INTRODUCTION

Milk and milk products, because of their high nutritional value, are components of the soldiers' ration and properly demand a place in any well-balanced diet. Their use by the people of the United States has increased to such an extent that dairies now constitute the country's largest single industry, producing fourteen billion gallons of cow's milk yearly. In spite of this, a local supply of cow's milk is not always available in quantity or quality for the use of military personnel. This is especially true in the Tropics where the native cow on native feed produces but little milk in excess of her calf's requirements. The daily supply available for the City of Manila amounts to only about 1,100 liters. There is about the same amount of carabao milk available, but this does not alter the situation for the military personnel.

Under these conditions, the Army has depended in the past largely upon canned evaporated milk. This has the advantage of being a sterile product and available in almost unlimited quantities. An undesirable feature in the use of canned evaporated milk is the prevailing method of piercing the top of the can with an ice pick or meat cleaver, pouring out part of the contents, and setting aside the remainder for future use in a condition easily subject to contamination.

In more recent years, whole-milk powder has been available. Its great advantage is the decrease in bulk through the removal of about 97 per cent of the water from the whole milk. As stated by Hunziker,(1) the disadvantages of whole-milk powder are the deterioration of the fat with age, the alteration of the flavor through the comparatively rapid changes that occur in the exposed powder, and the tendency to spoil under ordinary conditions of commercial storage and marketing. When vacuum packed in small containers, the deleterious changes occur more slowly, and the contents of the opened can are more apt to be used before oxygen and moisture can act on it. For use, whole-milk powder should be mixed in sterile containers with potable water and in such amounts as to assure consumption within a short period of time and the mixture must be handled as is natural milk.

A third form of concentrated milk is skim-milk powder. This is made from skim milk and contains from 2 to 4 per cent water and usually from 0.5 to 2 per cent butter fat. Hunziker states that properly manufactured skim-milk powders are comparatively stable and retain their freshness for many months, provided they are packed in air-tight, moisture-proof containers; but that they will eventually develop a stale flavor from changes in the fat, small in amount as the latter is compared with the 28 per cent of fat in whole-milk powder. It is used in cooking and in making reconstituted milk.[1]

Reconstituted milk is now produced by one firm in Manila and its use by the military personnel has grown to such an extent as to prompt the writer to investigate it from bacteriological, chemical, and biological standpoints.

Reconstituted milk is a homogeneous mixture of skim-milk powder, sweet (unsalted) butter, and water. The skim-milk powder is imported from California in wooden barrels and is held in cold storage until used. The powder is stated to be produced by the Gray-Jensen spray process. In this process the skim milk is preheated to about 170° F. in a storage tank by passing it through flash heaters connected with this tank, then pumped through a series of spray nozzles into a precondensing chamber where the milk is maintained at 165° F. by hot air circulating from the final drying chamber. At this point there is some evaporation. From this chamber it is pumped under about 2,500 pounds' pressure into the final drying chamber through overhead spray jets. Dry air at about 260° F. enters this chamber from the bottom and removes about 98 per cent of the moisture from the milk, which then falls to the bottom of the chamber as fine, flaky particles. This dried milk is drawn by air into a collection tank where it is fed into a hopper and through a flour bolter to insure the fineness of the powder. It is then run into the shipping containers.

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[1] An idea as to the extent to which these concentrated milks are used can be gathered from the statement in a publication of the Philippine Bureau of Animal Industry that it requires 55,000 acres of United States' land to pasture the cows that annually yield the 58,000,000 pounds of natural milk that are exported to the Philippine Islands in condensed and evaporated form. This constitutes approximately 80 per cent of the dairy products imported into the Islands.

Sweet (unsalted) butter is shipped from Australia, refrigerated, in wax-paper-lined wooden boxes of about 56 pounds' capacity. The available scores of the inspectors of the Australian Commonwealth show that the butter at the time of inspection in Australia is of the choicest quality. Butter to score this high can be made only from cream that is fresh and of high quality. On arrival in Manila the butter has a clean, pleasant flavor and aroma, necessary qualities to produce palatable reconstituted milk.

Reconstituted milk is made by agitating at a temperature of 143° F. for thirty minutes the proper amounts of sweet butter, milk powder, and artesian water in a glass-lined pasteurizer that is provided with a water-heated revolving spiral coil. This operation melts the butter, dissolves the powder, thoroughly mixes the ingredients, and pasteurizes the product. The milk, after running through tubular filters to remove any extraneous or undissolved matter, goes to a homogenizer where it is subjected to a pressure of from 2,500 to 3,000 pounds to the square inch. This thoroughly emulsifies the fat and prevents it from separating out in the bottled product. From the homogenizer the milk passes through an internal tubular cooler where its temperature is reduced to about 40° F. It is then bottled and capped by one machine, and another machine places hood caps over the tops of the bottles to protect their lips from contamination. The bottles are then placed in storage below 40° F. until delivery. The milk bottles and crates, before being used, are washed in a standard washing machine.

The advantages of properly prepared reconstituted milk are: first, the water and other ingredients used are pasteurized;

second, the containers are properly cleansed before being filled; third, from the time the ingredients are pasteurized and including the bottling of the product, there is no human contact.

BACTERIOLOGICAL EXAMINATIONS

The bacteriological examinations of the water used in the reconstituting plant and the *Escherichia coli* determinations were made according to the methods prescribed in Standard Methods of Water Analysis.(2) The macroscopic colony counts and Breed method counts were made as prescribed by the American Public Health Association and the Association of Official Agriculture Chemists.(3) The skim-milk powder was accurately weighed in sterile tared flasks and diluted 1: 10 with sterile freshly distilled water and shaken until dissolved. The macroscopic colony and Breed method counts were recorded as bacteria per gram of skim-milk powder.

Examinations for the presence of viable *Mycobacterium tuberculosis* in the butter and skim-milk powder were made as follows: Two grams of the butter were melted in warm normal salt solution and centrifuged, and the sediment and supernatant fat layer used for inoculations. Two grams of the milk powder were dissolved in 20 cubic centimeters of distilled water and centrifuged; the sediment was suspended in 5 cubic centimeters of normal salt solution and used for inoculation. The inoculations were made subcutaneously into the groins of guinea pigs. The animals were weighed and kept under observation for two months, when they were autopsied.

Examinations of the skim-milk powder, butter, water, and the finished product were made at monthly intervals. The bacteriological findings for three representative months are given in Table 1. The milk bottles prepared for filling were also examined at these intervals. The total bacterial content of these bottles ranged from 700 to 6,200 bacteria, averaging 2,500 bacteria per bottle. Monthly examinations of specimens of butter and skim-milk powder were negative for viable *Mycobacterium tuberculosis* by animal inoculations. Throughout this period samples of the water in five 10 cubic centimeter amounts and all other ingredients in 0.01 gram or cubic centimeter amounts were negative for *Escherichia coli.*

Additional macroscopic colony counts were made of seventy-two samples of the finished product over a period of six months. The maximum count was 30,600, the minimum count 400, averaging slightly less than 6,000 per cubic centimeter.

TABLE 1.—*Bacteria per gram or cubic centimeter of the ingredients and of the finished reconstituted milk by months.*

Specimen.	First examination.		Second examination.		Third examination.	
	Plate count per g or cc.	Breed count per g or cc.	Plate count per g or cc.	Breed count per g or cc.	Plate count per g or cc.	Breed count per g or cc.
Milk powder	490,000	60,900,000	300,000	44,000,000	180,000	31,000,000
Butter	62,000	------------	110,000	------------	73,000	------------
Water	[a] 2,200	------------	93	------------	260	------------
Finished product	10,500	890,000	7,200	690,000	17,000	330,000

[a] The initial examination of the water, which showed 2,200 bacteria per cubic centimeter, led to a more-efficient method of filtration and a marked reduction in the plate count on subsequent examinations.

As shown in Table 1, the bacterial plate colony count of the butter and water were found to be low. The plate colony count of the skim-milk powder was higher than would seem desirable. Plate colony counts of skim-milk powder are not an index of the number of bacteria in the original milk but indicate the number that survived drying or subsequently contaminated the powder.

The Breed count of the skim-milk powder was excessively high, indicating a probable high bacterial content of the fluid skim-milk used for drying. The experiments of Supplee and Ashbaugh(4) show that by the Breed count approximately 50 per cent of the bacteria disappear in milk dried by the Just hot roller process, but the percentage of bacteria that disappear in milk dried by the spray process is not known.

It is accepted that the Breed count on fresh natural milk is usually about four times as great as the plate colony count. The Breed counts made on the reconstituted milk averaged fifty-five times the number found by the plate colony count, and the Breed counts made on the skim-milk powder averaged approximately one hundred forty times the number found by the plate colony count. This, in the latter case at least, is due to the large number of bacteria killed during the process of drying the skim milk.

To arrive at an approximate effect of pasteurization on the bacterial content of the milk mixture, an estimate was made of the probable plate colony count of the mixture before pasteurization based on the plate colony counts of the milk powder, butter, and water adjusted to the amount of each that would be present in 1 cubic centimeter of the mixture. This estimate was compared with the actual plate colony count of the finished reconstituted milk made from these same ingredients on the same day. It was found that pasteurization, in two of the samples, reduced the theoretical number of viable bacteria to one-sixth, and in the third sample, the reduction was less than one-half. This difference may be explained as due either to temperature variation in pasteurization or by the presence of a greater proportion of bacteria thermostabile to the temperature used.

To determine the bacteriological and nitrogenous changes that take place in skim-milk powder as a result of storage, examinations were made of specimens from two original barrels and then portions of each specimen were stored in sterile, air-tight, glass jars at 45° F. Samples were removed and tested at intervals of two weeks for a period of two months and a final examination made at the end of five months.

TABLE 2.—*The nitrogenous and bacteriological changes in skim-milk powder in storage at 45° F.*

MILK POWDER, SPECIMEN A.

Date.	Plate count.	Breed count.	Total nitrogen.	Ammonia nitrogen.		Amino acid nitrogen.	
				In milk powder.	In total nitrogen.	In milk powder.	In total nitrogen.
1933	*Per gram.*	*Per gram.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Jan. 6	240,000	26,700,000	5.65	0.0208	0.368	0.240	4.25
Jan. 19	230,000	29,600,000	5.60	0.0311	0.555	0.273	4.88
Feb. 6	200,000	28,900,000	5.58	0.0267	0.478	0.302	5.41
Feb. 21	220,000	29,500,000	5.63	0.0276	0.490	0.267	4.74
Mar. 7	180,000	25,900,000	5.71	0.0315	0.551	0.308	5.39
June 6	93,000	23,300,000	5.59	0.0400	0.715	0.290	5.19

MILK POWDER, SPECIMEN B.

Date.	Plate count.	Breed count.	Total nitrogen.	Ammonia nitrogen.		Amino acid nitrogen.	
				In milk powder.	In total nitrogen.	In milk powder.	In total nitrogen.
Jan. 6	190,000	30,000,000	5.63	0.0233	0.410	0.198	3.51
Jan. 19	140,000	31,400,000	5.55	0.0273	0.492	0.274	4.94
Feb. 6	17,000	27,500,000	5.56	0.0239	0.429	0.301	5.41
Feb. 21	20,000	31,200,000	5.57	0.0277	0.496	0.288	5.17
Mar. 7	16,000	28,700,000	5.61	0.0263	0.469	0.299	5.33
June 6	9,000	28,200,000	5.57	0.3100	0.556	0.304	5.45

The results obtained are shown in Table 2. The initial Breed count was high in both samples of skim-milk powder and remained approximately the same in subsequent determinations during the period of storage, due consideration being given to the known variability of counts made by the Breed method.

Plate counts made from specimen A showed a gradual decrease on successive examinations, the initial count being 240,000 per gram and the final count 93,000 per gram. In specimen B the decrease was more pronounced, diminishing from the initial count of 190,000 to 9,000 per gram. The viable bacteria in specimen A were largely diplococci and staphylococci and in specimen B the predominating type was staphylococcus. As would be expected in a medium of low moisture content, plate colony counts of both specimens showed no active bacterial metabolism.

During the process of drying the bacterial content of the milk is markedly reduced, but the products of certain chemical changes in the fluid milk that have been brought about by the metabolism of great numbers of bacteria are not removed by drying. It is essential, therefore, that the milk used be produced and handled under sanitary conditions and that it be at least of the same standards required of milk for pasteurization.

CHEMICAL EXAMINATIONS

The physical changes that take place in skim-milk powder in storage are usually described as the development of a musty or a tallowy odor, a decreased solubility of the casein, and a darkening of the color. The chemical nature of these changes has not been conclusively determined, except that the tallowy odor is known to be brought about by the oxidation of the small amount of butter fat present. This can usually be confirmed by the Kreiss test.

Ferris(5) has discussed the nitrogenous substances found in milk and cream and states that it is the general opinion of dairy chemists that certain changes in these nitrogenous constituents begin at an early stage, probably from the action of enzymes and bacteria upon the proteins. The degree of this change depends principally upon the kind and amount of contamination and upon the temperature at which the product is held. Intermediary products of protein destruction are formed, the simplest of which are the amino acids. The more favorable the conditions for enzymic and bacterial activity, therefore, the greater should be the number of amino groups formed from the original protein.

Shrader et al.,(6) in their investigations of the sanitary quality of one hundred samples of commercial milk powders, state that there is a direct correlation between the ammonia nitrogen and the bacterial content, whereas the amino acids do not seem to bear such a relationship. They also state that ammonia constitutes the end nitrogenous product of bacterial metabolism and is therefore a truer measure of bacterial activity. From their findings they conclude that "excessive bacteria count before manufacture is indicated by the presence of an approximately proportional content of ammoniacal products."

The work of Shrader did not include the length of time and method of storage of the samples tested and no reference has been found in the available literature as to the influence of these factors on the nitrogenous decomposition products in milk powder.

As it appeared probable that these factors would have an important bearing on the nitrogenous decomposition products, the two stored samples of milk powder, discussed in the bacteriological section, were subjected to chemical examinations[2] in parallel with the bacterial counts during the five months' storage period. The determinations made were of total nitrogen, of ammonia nitrogen, and of amino acid nitrogen.[3]

Total nitrogen was determined on dry powder by the Kjeldahl-Gunning-Arnold method.(7) For the ammonia nitrogen, an aqueous solution containing a given amount of the milk powder was rendered alkaline with magnesium oxide and the mixture was distilled under reduced pressure. This distillate was caught in a known volume of 0.1 *N* sulphuric acid, and the excess acid was titrated back with 0.1 *N* sodium hydroxide, using Congo red as an indicator. Amino acid nitrogen was determined by the formol titration method of Malfatti.(8) The method consists essentially of adding solid potassium oxalate and neutral formaldehyde solution to the watery solution of the milk powder, and titrating the acid reaction produced in the mixture with 0.1 *N* standard alkali using phenolphthalein as an indicator, the free ammonia nitrogen being subtracted from the total titration.

The results of the chemical examinations are recorded, together with the bacteriological findings, in Table 2.

At the end of the five months' storage period both samples of milk powder showed a moderate darkening of color and a decreased solubility. There was a faint musty odor to both samples but no suggestion of a tallowy odor, and in both samples the Kreiss test for oxidation of fat was negative. However, some of the other samples of skim-milk powder from different shipments were slightly positive to the Kreiss test, although no tallowy odor could be detected.

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[2] The nitrogen determinations were made by Dr. J. Marañon, of the Bureau of Science, Manila, to whom the writer acknowledges his indebtedness.

[3] *Fat and total solids.*—Chemical examination of twenty-seven samples of the reconstituted milk showed an average fat content of 3.52 per cent and total solids of 12.81 per cent by the Babcock methods.

The successive nitrogenous determinations made on the two powders while held in storage showed an increase of ammonia nitrogen, and in the specimen in which the viable bacteria were greatly reduced by storage there was a definite increase in the amino acid nitrogen. These evidences of proteolytic changes indicate the presence of organic catalysts, enzymic in character, but whether they are native to the skim-milk powder or are the result of the metabolism or breaking down of bacteria could not be ascertained. It is probable that the proteolytic changes vary with the types of bacteria present in skim-milk powder, and whether the bacteria are living or dead.

As the ammonia nitrogen increased in both samples with the time held in storage, the statement of Shrader et al., that an ammonia nitrogen determination is a chemical confirmation of the bacterial content of the fluid milk used before manufacture, should at least be qualified to include the length of time and conditions of storage of the milk powder.

BIOLOGICAL EXAMINATIONS

It is a recognized fact that raw milk contains the various known vitamins in proportions as they exist in the feed of the lactating animal. The vitamin content of the feed is influenced by the seasons of the year and whether or not it is fresh and green, or dried. Thus milk from any one source may vary greatly in the amounts of vitamins present at different times during the year. This is especially true of vitamin C, which has been found to be in greater concentration in the milk in summer when cows are on pasture.(9) The instability at times of vitamin C in milk that is heated to high temperatures precludes powdered milk as a reliable source of this vitamin. The use of fresh fruits and certain vegetables, such as tomatoes, obviates the deficiency of this vitamin in the usual dietary.

Although milk is an excellent source of calcium and phosphorus, cow's milk may be deficient in vitamin D, as shown by Frank et al., of the United States Public Health Service.(10) In investigating the growth-promoting property of heated and raw milk, they found a rickets case rate of 31.5 per thousand in the heated-milk group and one of 51.1 per thousand for the raw-milk group. They considered the smaller rate for the heated-milk group as probably due to the increased cod-liver oil intake of this group. To prevent a possible deficiency of vitamin D, milk may be irradiated before or after drying to enhance its antirachitic properties. The possible slight decrease of vitamin A in the butter fat caused by irradiation would not be a factor in the irradiation of liquid or dried skim-milk.

Vegetable oils in general are notably deficient in vitamin A and should not, therefore, be used in place of butter in making fresh-milk substitutes. The vitamin A content of butter depends upon the type of feed of the lactating animal and upon the methods used in manufacturing and storing the butter.

Lately, vitamin B has been divided into at least two distinct entities, B (B_1) and G (B_2). The first, B (B_1), possesses antineuritic and growth-promoting properties and is considered as being thermolabile. In powdered milk this vitamin remains in varying degrees according to the reaction of the fluid milk and the temperature and methods used in drying. Vitamin G (B_2) is distinctly more stable at the temperatures and methods used in drying milk. It possesses growth-promoting properties and is also a preventive and cure of pellagralike symptoms in the rat.

As the two basic ingredients of reconstituted milk—skim-milk powder and butter—originate in such widely separated countries, biologic tests were carried out to determine the vitamin A, B (B_1), and G (B_2) value of the finished product.

Healthy rats weighing from 40 to 50 grams and from twenty-eight to thirty days old were used. The rats were of two types, albino, and black and white. They were bred in this laboratory from stock that had originally been imported from the United States.

In the vitamin A experiments the purified basal ration consisted of the following: Purified casein, 18 parts; dextrin, 60; Crisco, 8; salt mixture (McCollum's No. 185),(11) 4; agar-agar, 2; extract of tikitiki, 8.

In the vitamin B experiments the basal ration consisted of the following: Purified casein, 18 parts; dextrin, 62; butter, 8; Crisco, 6; salt mixture (McCollum's No. 185), 4; agar-agar, 2.

Both basal rations were irradiated at a distance of 30 inches for fifteen minutes by a quartz mercury vapor lamp to insure an adequate supply of vitamin D. To insure an adequate supply of vitamin G (B_2), four parts of autoclaved yeast were added to the basal ration fed to part of the rats on the vitamin-B-free ration plus the reconstituted milk. The basal rations were replenished daily, and the containers cleaned and sterilized twice weekly.

The following method was used in purifying the casein: It was first washed in distilled water, drained and washed daily for seven days with distilled water acidulated with acetic acid. After being pressed and dried it was placed in a Buchner filter and washed with 80 per cent alcohol, followed by 95 per cent alcohol, partly dried, and extracted for five hours with 95 per cent alcohol using a reflux condenser. The casein was then dried in a hot-air oven and was ready for use after being ground to a fine powder.

The dextrin was prepared by autoclaving cornstarch in a weak solution of citric acid water. The dextrinized cornstarch was then air dried and worked into a coarse powder.

The dried baker's yeast was autoclaved at fifteen pounds' pressure for six hours.

The butter fat was obtained by melting fresh butter and allowing it to stratify. The supernatant oil was recovered by decanting it from the water and curd.

Vitamin A in the reconstituted milk.—Male rats were used, and when pronounced symptoms of xerophthalmia appeared accompanied by loss in weight, the irradiated vitamin-A-free diet was supplemented with 10 cubic centimeters of reconstituted milk daily. Within two weeks the xerophthalmia had disappeared and a good rate of growth was established. These rats were later used for breeding with rats used in vitamin B experiments (fig. 1).

Vitamins B (B_1) and G (B_2) in the reconstituted milk.—Female rats were used in these experiments as it has been stated that rats of this sex require a greater amount of vitamin B for normal growth.(12) When the weights of the rats had declined and neuritis had appeared, the irradiated vitamin-B-free diet was supplemented with 20 to 30 cubic centimeters of reconstituted milk daily. This amount was found to be sufficient to cure the neuritis and to promote a fair rate of growth.

The vitamin-B-free ration of two of the rats was supplemented with four parts of autoclaved yeast at the time of the addition of the reconstituted milk. The rapid increase in weight of this group of rats over the rats receiving their vitamins B

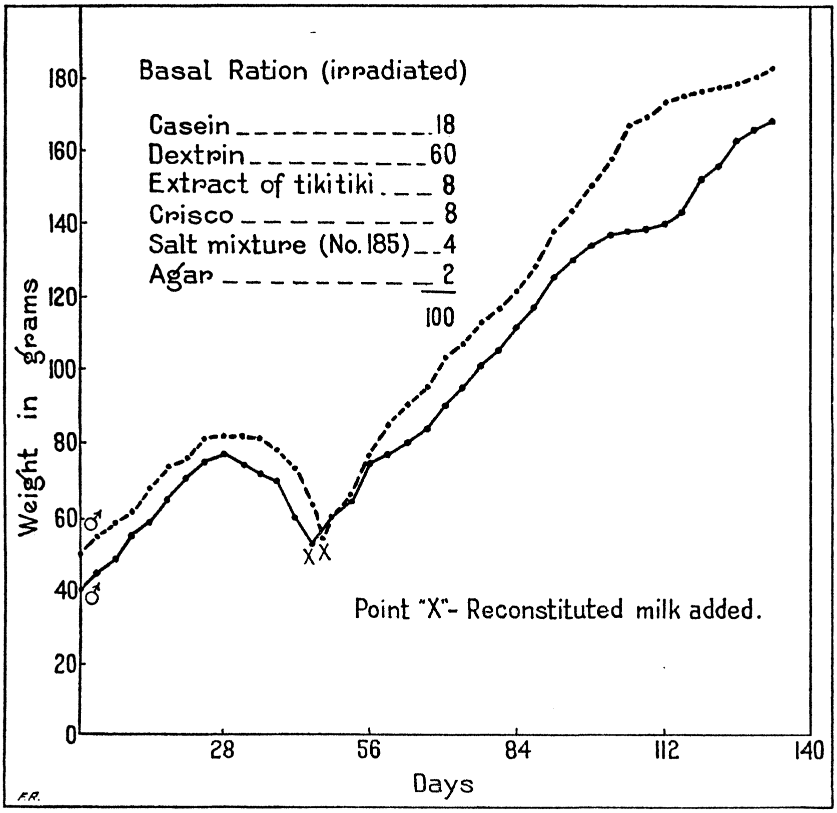

FIG. 1. Growth curve of two rats, showing the effect of adding 10 cubic centimeters of reconstituted milk daily to a vitamin-A-free basal diet. At the point X the rats had marked symptoms of xerophthalmia.

(B_1) and G (B_2) from the reconstituted milk alone indicates that, although milk when fed in the above-mentioned amounts contained sufficient B (B_1) to cure marked symptoms of neuritis and enough G (B_2) to promote a fair rate of growth, the amount of the latter factor was limited (figs. 2 and 3).

Two female rats, which were fed reconstituted milk in addition to the vitamin-B-free diet, and the two female rats fed the same diet plus autoclaved yeast were mated to the rats used in the vitamin-A tests. One female that did not receive yeast did not conceive. The others bore and reared normal litters.

SUMMARY

Studies were made of a reconstituted milk that is produced in Manila, Philippine Islands. This is prepared from skim-milk powder shipped from California and butter from Australia to

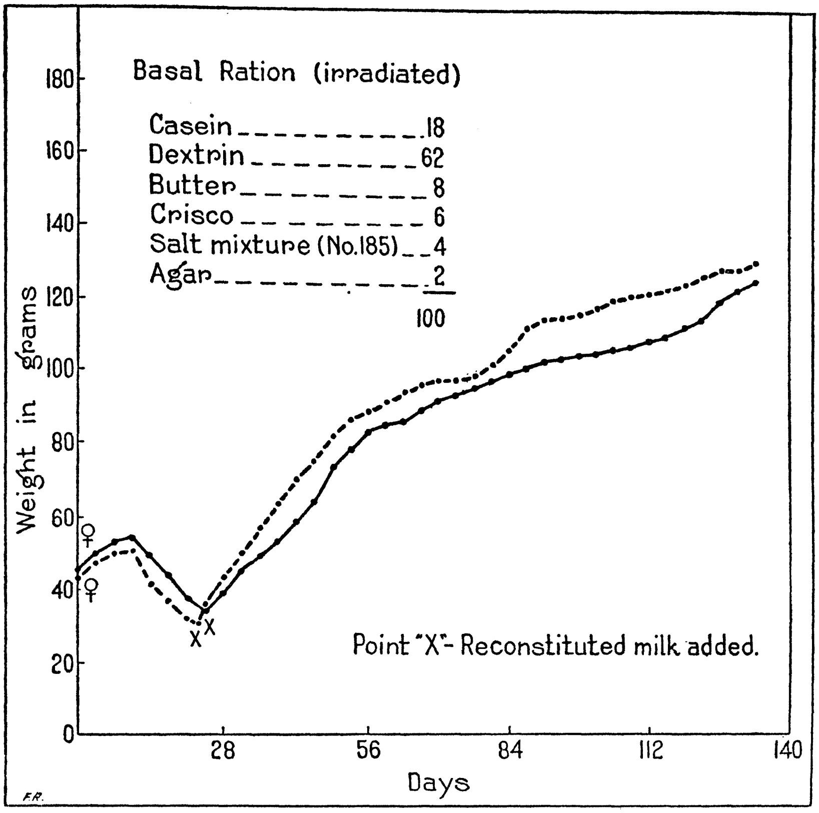

FIG. 2. Growth curve of two rats, showing the effect of adding 20 to 30 cubic centimeters of reconstituted milk daily to a vitamin B (B_1) and G (B_2) free basal diet. At the point X the rats had marked symptoms of neuritis.

which is added water obtained from an artesian well on the premises of the reconstituting plant. The product is pasteurized in the reconstituting process and bottled in the usual manner for pasteurized whole milk. Bacteriological, chemical and biological examinations were carried out on the reconstituted milk and its ingredients.

The viable bacteria in the skim-milk powder, as determined by the plate count, was higher than would seem desirable although within the range of normal expectancy. The Breed counts of the skim-milk powder, while not higher than the average of available figures, would indicate that greater care should be taken in the production and handling of fluid milk used for drying. Plate colony counts of the butter and water were well within reasonable limits. Plate colony counts and total solids content, including fat, of the reconstituted milk show it to com-

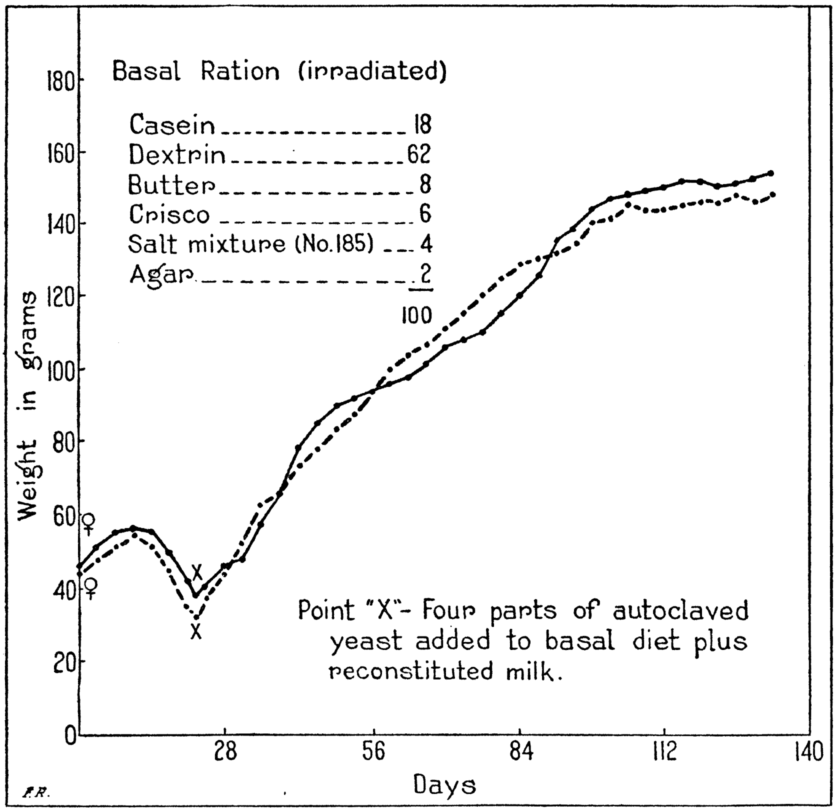

FIG. 3. Growth of two rats, showing the effect of adding four parts of autoclaved yeast and 20 to 30 cubic centimeters of reconstituted milk daily to a vitamin B (B_1) and G (B_2) free basal diet. At the point X the rats had marked symptoms of neuritis.

ply, in these two particulars, with the prescribed limitations for Grade "A" pasteurized milk.

Animal inoculations of the skim-milk powder and butter were negative for viable *Mycobacterium tuberculosis.*

When held in storage for five months two samples of skim-milk powder, although showing a progressive decrease in viable bacteria, showed a progressive increase of ammonia nitrogen.

In the biological experiments conducted it was found that the reconstituted milk in daily amounts of 10 cubic centimeters contained sufficient vitamin A to cure rats with xerophthalmia and establish a good rate of growth. In daily amounts of from 20 to 30 cubic centimeters the milk was found to contain sufficient vitamins B (B_1) and G (B_2) to cure rats with marked neuritis and to promote a fair rate of growth.

CONCLUSION

When prepared in a properly equipped reconstituting plant, using standard ingredients, a fluid milk can be made from skimmilk powder, sweet (unsalted) butter, and water that will closely approximate pasteurized cow's milk.

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ILLUSTRATIONS

TEXT FIGURES

FIG. 1. Growth curve of two rats, showing the effect of adding 10 cubic centimeters of reconstituted milk daily to a vitamin-A-free basal diet. At the point X the rats had marked symptoms of xerophthalmia.

2. Growth curve of two rats, showing the effect of adding 20 to 30 cubic centimeters of reconstituted milk daily to a vitamin B (B_1) and G (B_2) free basal diet. At the point X the rats had marked symptoms of neuritis.

3. Growth curve of two rats, showing the effect of adding four parts of autoclaved yeast and 20 to 30 cubic centimeters of reconstituted milk daily to a vitamin B (B_1) and G (B_2) free basal diet. At the point X the rats had marked symptoms of neuritis.

A SCLEROTIUM SEED ROT AND SEEDLING STEM ROT OF MANGO[1]

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TWELVE PLATES AND ONE TEXT FIGURE

In August, 1930, sclerotia of a soil-inhabiting fungus of the genus *Sclerotium* were found clinging to dead mango seedlings in a neglected nursery in Muntinlupa Plantation, Rizal Province, Luzon. The fungus appeared to be of little pathological significance, and was not investigated at the time. In the latter part of May, 1931, the nursery was cleaned and a few thousand mango seeds planted, the seedlings to be used for replacements in a new mango plantation. During the second half of June, following unusually wet weather, a severe outbreak of *Sclerotium* disease occurred on these plants. The sclerotia produced by the fungus appeared to be identical with those found in August, 1930, in the same nursery. Several of the seeds failed to germinate and many of the seedlings died. The disease progressed rapidly in July, as the seedbeds were always wet during this month of heavy precipitation.

The dead seedlings showed the white growth of mycelium and sclerotia of the causal fungus at the base of the stems and also on the surface of the soil around the plants. The rapid spread of the disease may have been occasioned by the movement of surface water during heavy rains or by the processes of cultivating, weeding, and watering the plants. By August, 10 per cent of the seedlings had died. The percentage of seeds that failed to germinate could not be ascertained, since there was no record of the number of seeds originally planted, but it is believed that the mortality was higher than in the case of the seedlings.

No *Sclerotium* disease on mango seedlings is reported from any country except the Philippine Islands. In a compiled list of hosts of *Sclerotium rolfsii* Sacc. made by Weber(8) for the United States and foreign countries in 1931, the mango is not included. In 1911, Wester(10) mentioned a species of *Sclerotium* associated with damping-off of mango seedlings in soil that had been kept too wet, but the disease was not studied. As it appears to be increasing in importance and tends to become a factor in the culture of mango seedlings in the nursery the present investigation was considered advisable.

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[1] The writer wishes to thank Dr. G. O. Ocfemia, Head of the Department of Plant Pathology, College of Agriculture, University of the Philippines, for reading the manuscript.

DESCRIPTION OF THE DISEASE

The early indication of the disease is the development of a white mycelial weft on the stem at the ground level. Beneath the mycelial growth a dark brown lesion may be noted. In a severe infection, especially when the seedling is young or has newly emerged, the lesion may be seen in advance of the growing mycelium. While the disease progresses, the leaves begin to turn somewhat pale, but not markedly discolored, and wilt, after the mycelium has completely encircled the base of the stem (Plate 1, fig. 1). When young, rapidly growing seedlings are attacked, the succulent top droops or bends towards the ground because the tissues lose turgidity. Old seedlings killed by the disease stand erect. Under favorable conditions the fungus mycelium may be seen encircling the stem to a height of an inch or more above the ground level. In a little more advanced stage of the disease the sclerotia, which are white at first and brown with age, develop on the dead tissues and also on the surface of the soil upon which the mycelium has spread. Weather conditions unfavorable to the growth of the fungus, together with the hardening of the tissues of the growing seedlings, may hinder the progress of the disease, and if the infection is not severe the plant recovers and resists further infection. The seedlings that have recovered in this manner may show constrictions or cavities produced by the fungus on the tissues at the base of the stems.

In a few cases the newly-emerged seedlings may show signs of wilting without any evident lesion at the base. When such seedlings are pulled out the cotyledons may show an advanced stage of rotting due to the disease.

The seedlings severely attacked may die within a week after the infection becomes noticeable. The roots of the dead seedlings become soft and black, and the sclerotia of the causal fungus may be seen adhering to the cotyledons (Plate 2, fig. 1).

The disease also causes a severe rotting of the seeds in the beds before or during germination. Under favorable conditions the fungus on the dead seed may further develop and the mycelium may grow through the soil and produce numerous sclerotia on the surface over the dead seed (Plate 2, figs. 2 and 3).

CAUSAL ORGANISM

METHOD OF ISOLATION AND PREPARATION OF SUBCULTURES

Several sclerotia that were found associated with the decaying cotyledons of a diseased mango seedling were immersed in 1:1,000 mercuric chloride solution for thirty seconds, washed with three changes of sterile water; then each sclerotial body was plated out on sterile potato-glucose agar. Stock cultures were made by transferring the sclerotia that developed from a single colony. The cultures used in the subsequent studies, unless otherwise stated, were made by plating out a single sclerotial body obtained from the stock culture and then transferring, before the growth produced sclerotial bodies, blocks of the agar 3 millimeters square, containing the hyphæ of the fungus. The blocks were cut from the margin of the growth and placed upside down upon the agar so that the mycelium might have a direct contact with the fresh medium.

MORPHOLOGY

Mycelium.—When a sclerotial body is plated out on sterile agar medium it produces coarse white threads, which radiate in all directions from the sclerotium. The coarseness of the mycelial growth is due to the development of strands (Plate 3, fig. 1), which consist of a group of more or less parallel hyphæ that have grown closely together. The larger hyphæ develop at certain of the septa a clamp connection, opposite which a hyphal bud frequently arises and grows generally parallel to the main thread (Plate 3, fig. 3). Similar structures were reported by Higgins(1) in *Sclerotium rolfsii* Sacc. and by Welch,(9) Takahashi,(5) and Stevens(4) in *Sclerotium delphinii* Welch. A group of hyphæ of this kind may anastomose and grow closely together, developing into strands that impart coarseness to the growth. In certain plates of 25-day-old lactose-beef-agar and dextrose-beef-agar cultures, the mango *Sclerotium* produced pinkish cinnamon[2] patches consisting of strands of short barrel-shaped cells (Plate 3, fig. 2) and hyphæ with knotlike structures (Plate 3, fig. 4). Also, on these two media the fungus under certain conditions developed mats of loosely interlaced lobulate hyphæ (Plate 3, fig. 5), which were perhaps special feeding structures of the fungus. As the sclerotia harden the mycelial growth is gradually depressed to the level of the medium. A comparison of the average measurements of the hyphæ of the mango *Sclerotium* with *Sclerotium rolfsii* Sacc. isolated from pepper, rice, and tomato, and with four strains of *Sclerotium delphinii* Welch (Table 1) showed no marked difference in their diameters.

TABLE 1.—*Comparative diameters of hyphæ of various races of Sclerotium from 3-day-old plate cultures on potato-glucose agar.*

Race.[a]	Diameter of hyphæ based on 100 measurements.	
	Range.	Average.
	Microns.	*Microns.*
Sclerotium on mango	1.70–10.00	4.60
Sclerotium rolfsii on pepper	1.60– 8.30	4.58
Sclerotium rolfsii on rice	1.50– 9.13	4.51
Sclerotium rolfsii on tomato	1.50– 8.35	4.60
Sclerotium delphinii W–517	1.40–10.50	4.60
Sclerotium delphinii I	1.60–10.50	4.70
Sclerotium delphinii II	1.68–11.20	4.60
Sclerotium delphinii III	1.40–10.50	4.80

[a] The cultures of *S. rolfsii* from pepper and rice were obtained from Mr. Gaudencio M. Reyes, assistant mycologist, and the one from tomato came from Dr. T. G. Fajardo, plant pathologist. The cultures of *S. delphinii* were obtained by Doctor Fajardo from the United States; *S. delphinii* labeled Wisconsin No. 517 from the plant pathology laboratory of the University of Wisconsin and *S. delphinii* I, *S. delphinii* II, and *S. delphinii* III from Dr. F. L. Stevens, of the University of Illinois.

Sclerotia.—The sclerotia herein described were those produced by the mango *Sclerotium* in plate cultures and in nature. In plate cultures the sclerotia first appear as white tufts of interlaced hyphæ on the surface of the fungous growth or at the ends of mycelial strands. Sometimes the sclerotia are formed first as enlarged white bodies on distinct stalks 1 to 5 millimeters in length. In a few plate cultures on potato-glucose agar numerous white tufts, some of which gave rise to the formation of stalk-bearing sclerotia, were noted to have developed (Plate

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[2] The color nomenclature followed is that of Ridgway, Robert, Color Standards and Color Nomenclature. Washington, D. C. (1912).

4, fig. 1). However, many of these white tufts did not continue to develop into sclerotia and became inconspicuous with age. At first without a definite boundary, a sclerotial body later develops a cortical layer of hard colored tissue. The larger sclerotia exude droplets of clear liquid from several points on their surface (Plate 4, fig. 1). On media rich in food, such as steamed oatmeal, this exudate becomes amber-colored as the culture ages. The points of exudation are often marked by sunken spots or pits (Plate 4, fig. 2), which are usually round and distinct on larger sclerotia (Plate 5, fig. 3), but generally absent or inconspicuous on smaller ones.

On favorable media the sclerotia produced are very irregular in shape and size; some are subglobose, others elongate or nearly spheroidal, but on media lacking in nutriment they assume a globose form and tend to become uniform in size. The larger sclerotia are not only pitted but also often flattened and concave on the ventral sides (Plate 5, fig. 2). Hilumlike scars (Plate 5, fig. 1) may be found on the ventral portions of some sclerotia at points where they are attached to the mycelial columns or strands. The development of sclerotia may begin after six or seven days on very poor media and after eight or more days on media rich in food. As the sclerotia mature on potato-glucose agar, the surface color turns to ochraceous-buff, finally to Hay's brown or occasionally tawny. On other media, however, the color of the sclerotia may differ slightly in shade from those produced on potato-glucose agar. On nearly all media tried the fungus tends to unite the sclerotia into irregular aggregations 5 to 10 millimeters in extent. The production of similar masses of sclerotia is reported by Taubenhaus(7) and Edson and Shapovalov(1) in *S. rolfsii* and by Welch(9) in *S. delphinii.*

The sclerotia produced on potato-glucose agar vary in diameter from 0.9 to 3.8 millimeters, the greatest number falling under 2 millimeters. According to Table 4 the fungus produces larger sclerotia on media prepared from plant decoctions than on those containing animal protein. On steamed oatmeal and soil-cornmeal[3] the sclerotia were extremely variable in shape and size, being 0.9 to 12.5 millimeters on steamed oatmeal and 1.5 to 7.5 millimeters on soil-cornmeal.

A section of a mature sclerotial body produced in culture shows that it consists of pseudoparenchymatous tissues with intercellular cavities and inclosed by a hard, compact layer of colored cells (Plate 3, fig. 7). This layer may be from one to four cells thick. The composite sclerotia, which were sometimes produced on steamed oatmeal, appeared spongelike in texture (Plate 5, fig. 4), and when sectioned the tissue consisted of loose hyphal wefts (Plate 3, fig. 6), especially at points where the pits were markedly shown.

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[3] One part by weight of cornmeal to 4 parts of soil.

The sclerotia produced in nature are generally globular and smooth and are smaller and more uniform in size than those produced on artificial media. They develop either from the white tufts of intertwined hyphæ on the diseased tissues or laterally from the mycelial strands (Plate 12) that creep upon the surface of the soil from the lesion. Upon maturity they turn from white to either cacao brown or chocolate and vary in diameter from 0.6 to 1.6 millimeters.

The sclerotia germinate usually by the production of individual mycelial threads from points which come in contact with the medium. Sometimes the large pitted sclerotia send forth a dense fascicle of mycelium from the pits. In infection experiments in the greenhouse, many of the freshly matured pitted sclerotia, which were placed on very moist soil in pots, produced mycelial fascicles that bore new but smaller sclerotia after six to eight days.

Sporiferous stage.—No effort was made to induce the fungus to produce spores. As far as observed the mango *Sclerotium* produces spores neither in culture nor under field conditions, and will therefore be classed for the present as one of the members of the mycelia sterilia group of Fungi Imperfecti.

COMPARATIVE DEVELOPMENT OF THE MANGO SCLEROTIUM, S. ROLFSII AND S. DELPHINII, ON CERTAIN MEDIA

Eight strains of *Sclerotium* were used in this study, a single culture on a standard 100-millimeter Petri dish being prepared for each strain on each medium. A sufficient amount of the medium was used to make a layer about 6 millimeters thick in each plate. The cultures of each organism were made from a 3-day culture on potato-glucose agar by cutting out a 3-millimeter block of agar near the margin of the growth and transferring it to the culture dish. The cultures were incubated at room temperature (28° to 32° C.). The results of this study are given in Table 2.

TABLE 2.—*Showing the comparative rate and profuseness of growth and sclerotial production of eight races of Sclerotium on some common media.*

Culture medium and race of *Sclerotium*.	Average diameter of colonies after three days.	Profuseness and thickness of mycelial growth.[a]	Average number of sclerotia produced in each plate.	Diameter of sclerotia.
Potato-glucose agar:	*mm.*			*mm.*
Mango *Sclerotium*	71.0	+++	44	0.9- 3.7
S. delphinii W-517	66.0	+++	49	1.1- 4.1
S. delphinii I	66.5	+++	58	0.9- 4.0
S. delphinii II	63.0	+++	18	1.0- 5.5
S. delphinii III	48.5	+++	46	1.2- 4.5
S. rolfsii on pepper	63.9	+++	396	0.7- 1.6
S. rolfsii on rice	67.4	+++	575	0.7- 1.3
S. rolfsii on tomato	70.8	+++	678	0.7- 1.2
Carrot-glucose agar:				
Mango *Sclerotium*	57.0	+++	10	2.0- 3.7
S. delphinii W-517	61.0	++	10	2.2- 6.7
S. delphinii I	62.0	++	10	1.7- 5.4
S. delphinii II	58.0	++	7	1.4- 8.1
S. delphinii III	37.0	++	9	2.2- 4.8
S. rolfsii on pepper	67.5	+++	196	1.0- 2.3
S. rolfsii on rice	64.0	+++	275	0.8- 2.2
S. rolfsii on tomato	70.0	+++	291	0.8- 1.5
Oatmeal agar:				
Mango *Sclerotium*	55.0	+++	8	1.5- 3.0
S. delphinii W-517	60.0	++	4	1.5- 5.1
S. delphinii I	69.0	++	3	2.2- 4.3
S. delphinii II	60.0	++	2	2.1- 5.5
S. delphinii III	46.0	+	2	1.9- 4.1
S. rolfsii on pepper	73.1	+++	63	0.7- 1.4
S. rolfsii on rice	65.9	+++	113	0.6- 0.9
S. rolfsii on tomato	67.5	+++	144	0.6- 0.9
Cornmeal agar:				
Mango *Sclerotium*	54.5	+++	4	1.5- 4.1
S. delphinii W-517	59.0	++	6	1.4- 3.2
S. delphinii I	59.0	++	4	2.1- 3.5
S. delphinii II	53.0	++	2	2.3- 4.5
S. delphinii III	36.0	+	1	3.2- 3.7
S. rolfsii on pepper	59.5	+++	115	0.7- 1.6
S. rolfsii on rice	56.8	+++	198	0.8- 1.4
S. rolfsii on tomato	58.6	+++	241	0.8- 1.5
Dextrose-beef agar:				
Mango *Sclerotium*	57.0	+++	19	1.0- 3.0
S. delphinii W-517	49.4	++	8	0.9- 3.1
S. delphinii I	55.6	++	12	1.2- 4.5
S. delphinii II	51.8	++	3	1.2- 3.5
S. delphinii III	20.8	+	7	1.0- 2.6
S. rolfsii on pepper	60.5	+++	587	0.6- 1.0
S. rolfsii on rice	63.0	+++	784	0.6- 1.0
S. rolfsii on tomato	62.6	+++	874	0.5- 0.9

[a] Meaning of symbols: +, Scant growth; ++, moderate; +++, abundant; ++++, very abundant.

TABLE 2.—*Showing the comparative rate and profuseness of growth and sclerotial production of eight races of Sclerotium on some common media*—Continued.

Culture medium and race of *Sclerotium*.	Average diameter of colonies after three days.	Profuseness and thickness of mycelial growth.[a]	Average number of sclerotia produced in each plate.	Diameter of sclerotia.
Saccharose-beef agar:	*mm.*			*mm.*
Mango *Sclerotium*	52.0	+++	26	1.1– 3.2
S. delphinii W-517	52.0	++	16	1.0– 3.3
S. delphinii I	55.0	++	25	1.2– 4.3
S. delphinii II	50.0	++	9	1.0– 3.5
S. delphinii III	28.0	+	4	1.9– 3.0
S. rolfsii on pepper	54.5	+++	133	0.8– 1.5
S. rolfsii on rice	51.1	+++	387	0.5– 1.3
S. rolfsii on tomato	51.0	+++	354	0.5– 1.2
Steamed oatmeal:				
Mango *Sclerotium*	56.0	++++	114	[b] 1.0–12.5
S. delphinii W-517	45.5	++++	85	1.6– 6.0
S. delphinii I	45.0	++++	383	1.9– 6.4
S. delphinii II	47.5	++++	59	2.2– 7.5
S. delphinii III	27.5	++++	28	1.3– 4.6
S. rolfsii on pepper	47.3	++++	3,913	0.7– 2.4
S. rolfsii on rice	49.1	++++	6,352	0.7– 2.0
S. rolfsii on tomato	59.6	++++	6,405	0.7– 2.2
Steamed cornmeal:				
Mango *Sclerotium*	59.5	++++	101	1.2– 4.5
S. delphinii W-517	51.0	++++	66	1.2– 8.2
S. delphinii I	48.7	++++	162	2.2– 4.6
S. delphinii II	56.7	++++	63	2.8– 9.2
S. delphinii III	26.6	++++	26	1.3– 5.6
S. rolfsii on pepper	60.9	++++	2,369	0.7– 2.5
S. rolfsii on rice	62.2	++++	2,825	0.7– 2.4
S. rolfsii on tomato	64.3	++++	3,065	0.7– 2.6

[a] Meaning of symbols: +, Scant growth; ++, moderate; +++, abundant; ++++, very abundant.

[b] The measurements indicated here include the composite sclerotia that were spongelike in texture.

In the character of mycelial growth no significant differences were noted among the races of *Sclerotium* used in this study. The slight differences observed in the profuseness and rate of growth were not sufficient to distinguish one strain from another. According to Table 2 *S. delphinii* III has the distinction of growing less rapidly than any other strain on all media. During the first three days of growth of the mango *Sclerotium* the mycelium showed characteristics similar to those of *S. delphinii* I, *S. delphinii* II, and *S. delphinii* W–517, but as the culture aged the growth became thick and floccose like that of

S. rolfsii. The growth of *S. delphinii* III was conspicuously dendritic, especially on carrot-glucose agar. Upon maturity of the sclerotia, the mycelial growth of all the strains growing on agar media became inconspicuous but this occurred much sooner in *S. delphinii* strains than in the mango *Sclerotium* and *S. rolfsii.*

Some differences were noted in the length of time necessary for the sclerotia to begin to develop. The mango *Sclerotium* produced sclerotia after eight or more days on agar media, while *S. rolfsii* and *S. delphinii* strains produced them after four to five days; in the case of *S. delphinii* III, owing perhaps to its slower growth than any other strain of *S. delphinii,* six to seven days were required. Sclerotial production by all cultures began much later on nutritive media, such as steamed oatmeal, than on agar media because the vegetative growth could go on longer.

The most striking difference between *S. rolfsii* and either mango *Sclerotium* or *S. delphinii* was in the size and number of sclerotia produced; those of the mango *Sclerotium* and *S. delphinii* strains were conspicuously larger and less numerous than those of *S. rolfsii.* The sclerotia of *S. rolfsii* are cinnamon brown or olive brown, smooth, generally globose and nearly uniform in size; those of the mango *Sclerotium* and *S. delphinii* are Hay's brown or tawny, surface-marked, concave or flattened on the ventral sides, and extremely variable or irregular in shape and size.

As shown in Table 2 the sclerotia of the mango *Sclerotium* and *S. delphinii* strains are not only larger but also of very much wider range of variation than those of *S. rolfsii.* On potato-glucose agar the sclerotia produced by each strain in a number of culture dishes were collected and then the diameters of 200 sclerotia were measured by calipers and arranged in classes varying by 0.1 millimeter. The results of these measurements, with the exception of those of pepper and tomato strains of *S. rolfsii,* are shown in fig. 1. The greater number of sclerotia fell in the diameter class 2.0 to 2.5 millimeters in *S. delphinii* strains; 1.7 to 2.4 millimeters in the mango *Sclerotium;* and 0.9 to 1.1 millimeters in the rice strain of *S. rolfsii.* With the strains of *S. rolfsii* not represented in fig. 1 they fell between 1.0 and 1.2 millimeters in the pepper strain and between 0.8 and 1.0 millimeter in the rice strain.

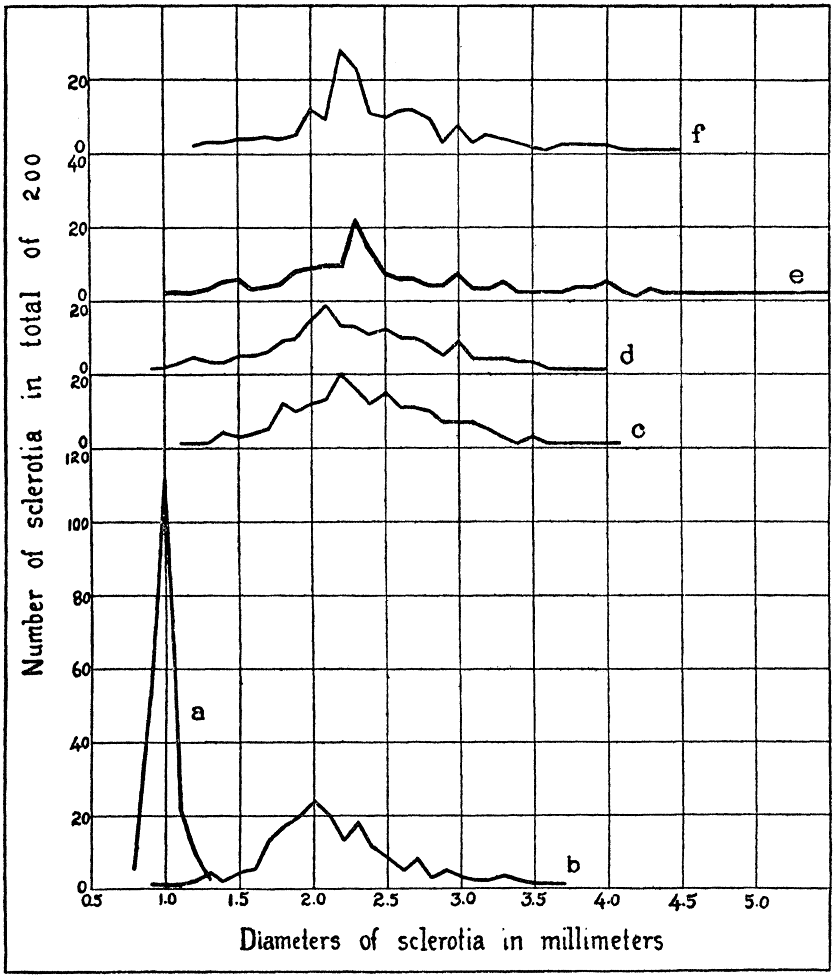

FIG. 1. Graphs showing sclerotial size of six strains of *Sclerotium* obtained from plate cultures on potato-glucose agar. *a*, *Sclerotium rolfsii* on rice; *b*, *Sclerotium* on mango; *c*, *Sclerotium delphinii* W-517; *d*, *Sclerotium delphinii* I; *e*, *Sclerotium delphinii* II; *f*, *Sclerotium delphinii* III.

COMPARATIVE RATE OF GROWTH AND PRODUCTION OF SCLEROTIA OF MANGO SCLEROTIUM, S. DELPHINII, AND S. ROLFSII AT DIFFERENT TEMPERATURES

In these studies seven strains of *Sclerotium* were used; namely, *Sclerotium* on mango, *S. rolfsii* on rice, *S. rolfsii* on tomato, *S. delphinii* W–517, *S. delphinii* I, *S. delphinii* II, and *S. delphinii* III. At each temperature eight standard Petri dishes, containing about 18 cubic centimeters of potato-glucose agar, were used for each strain. A mature fresh sclerotium, obtained from the plate cultures of each strain on potato-glucose agar, which had been incubated at room temperature, was transferred to the middle of each dish, and the cultures were distributed to four incubation chambers that were maintained at temperatures of 35° to 35.5° C., 28° to 32° C. (room temperature), 19° to 20° C., and 6° to 8° C., respectively, for twenty days. Incubators adjusted to cover the entire range of growth were not available. The results of these studies are given in Table 3 and shown in Plates 6 and 7. In Plate 6 only *S. rolfsii* on rice, the mango *Sclerotium*, and *S. delphinii* I are represented; in Plate 7 all are represented except *S. rolfsii* on tomato.

TABLE 3.—*Showing the average diameter of eight colonies each of the seven races of Sclerotium grown at different temperatures for four days in plates of potato-glucose agar.*

Race.	35° to 35.5° C.	28° to 32° C. (room temperature).	19° to 20° C.	6° to 8° C.
	mm.	*mm.*	*mm.*	*mm.*
Sclerotium on mango	6.6	90.0	39.0	0
Sclerotium rolfsii on rice	24.0	88.0	9.0	0
Sclerotium rolfsii on tomato	26.0	87.0	8.0	0
Sclerotium delphinii W–517	5.5	86.7	20.6	0
Sclerotium delphinii I	6.6	88.0	23.5	0
Sclerotium delphinii II	6.2	78.7	22.5	0
Sclerotium delphinii III	5.5	62.2	18.5	0

It may be seen in Table 3 that the most vigorous growth of all the strains occurred at room temperature (28° to 32° C.), at which no significant difference in the rate of growth of any strain was noted, with the exception of the less rapid growth of *S. delphinii* III. A little difference was noted in the time necessary for the sclerotia to begin development. The rice and tomato strains of *S. rolfsii*, *S. delphinii* W–517, *S. delphinii* I, and *S. delphinii* II produced sclerotia after four to five days; *S. delphinii* III, after six to seven days; mango *Sclerotium*, after eight to ten or more days. The production of numerous sclerotia distinguished the strains of *S. rolfsii* from the strains of *S. delphinii* and the mango *Sclerotium*. In general the mango *Sclerotium* and strains of *S. delphinii* produced less than one-tenth as many sclerotia as *S. rolfsii*.

At 35° to 35.5° C. the mango *Sclerotium* and strains of *S. delphinii* did not germinate as readily as the rice and tomato strains of *S. rolfsii*, since germination became apparent about twenty-four or more hours after the strains of *S. rolfsii* had shown visible growth. The subsequent development was very slow and before the fungous growth reached 10 millimeters in diameter the cultures ceased to grow. When a few plates of each strain were removed and subjected to room temperature, the growth started anew and covered the surface of the plates after four days. This indicates that this temperature is unfavorable to the growth of the fungus and perhaps, after prolonged exposure, fatal to the growth of the mango *Sclerotium* and *S. delphinii* strains. The critical temperature for these fungi, therefore, must be a little higher than 35.5° C. On the other hand, the strains of *S. rolfsii,* although slightly affected in growth, continued to develop until, after six days, they produced sclerotia that showed much wider variability in size than those produced by the same strains at room temperature.

At 19° to 20° C. the mango *Sclerotium* showed more vigorous growth than any of the strains of *S. delphinii,* while the rice and tomato strains of *S. rolfsii* showed less rapid growth. The sclerotia produced (Plate 7) by all the strains appeared to be slightly smaller, but less variable in size, than those produced at room temperature. Actual counts showed that the mango *Sclerotium, S. delphinii* W–517, *S. delphinii* I, and *S. delphinii* II had produced on the average more sclerotia at this temperature than at room temperature.

At 6° to 8° C. no germination of any of the strains occurred, but the sclerotia were not killed by the twenty days' exposure, since germination occurred after twelve hours when the plates were removed and placed at room temperature.

It may be seen from the above that the mango *Sclerotium* is in closer agreement with *S. delphinii* than with *S. rolfsii* with respect to temperature relations. The strains of *S. rolfsii* are markedly different from the mango *Sclerotium* and from strains of *S. delphinii* in that they showed better development at higher temperatures but less growth at lower temperatures.

THE SCLEROTIUM ISOLATED FROM MANGO IS A DISTINCT RACE OF SCLEROTIUM

In his studies of the phenomenon of aversion in *S. rolfsii,* Nakata(4) reports that when transfers from two different strains of this species are planted side by side in the same plate the growths stop at points where the mycelium from the two sources nearly meet, leaving a narrow region of the medium free from hyphæ. According to this author the submerged hyphæ at the clear regions show plasmolysis and then disintegration, while the aërial mycelia become fine and slender and curl backward. Likewise, Stevens(5) states that when any two of the races of *Sclerotium delphinii* Welch were planted upon cornmeal agar in a single Petri dish, a band extending across the plate was formed at the line of junction of the two colonies and "when any races were grown against another colony of the same race the mycelium of the two colonies mingled freely and no abnormal branching resulted." Following the studies made by Nakata and Stevens, two mature sclerotia of mango *Sclerotium* were inoculated upon one side of a Petri dish containing potato-glucose agar and another two mature sclerotia of *S. rolfsii* upon the opposite side of the plate. An aversion took place between the colonies (Plate 8, figs. 1, 2, and 3) obtained from any two cultures used. In rare cases, however, more sclerotia were formed at the free region than in other places in the plate. Along the junction line the hyphæ from the colonies of the mango organism became slightly discolored. Subsequently these colored hyphæ crept over the free space and then ceased to grow when they touched the hyphæ from the neighboring transfer. Aversion took place also when any two strains of *S. rolfsii* were allowed to grow on the same medium in a single Petri dish (Plate 8, figs. 4, 5, and 6).

The above study was repeated using *S. delphinii* W–517, *S. delphinii* I, *S. delphinii* II, *S. delphinii* III, and the mango *Sclerotium* in plates containing cornmeal agar. A band extended across each plate between the growths of a strain of *S. delphinii* and the mango *Sclerotium* (Plate 9). There was no evidence of antagonism between the growths that developed from the sclerotia from the same culture as shown by the absence of the fungus-free band on the media. It was also noted that although the growth of the mango *Sclerotium* on cornmeal agar was more luxuriant than that of any of the strains of *S. delphinii* it showed after eight days only incipient formations of sclerotia, while each strain of *S. delphinii* had developed a number of them. The mango *Sclerotium* may produce either sclerotia or white sterile loose lumps of hyphæ where its mycelium comes in contact with the hyphæ from a strain of *S. delphinii*. These characteristics are not exhibited when two or more transfers of the mango *Sclerotium* are planted in the same culture dish. On the other hand a strain of *S. delphinii* produced scattered sclerotia and did not develop white loose lumps of hyphæ where its growth came in contact with the growth of the mango *Sclerotium*. From the results of this experiment it seems that all of the strains of *S. delphinii* exerted some repellant or antagonistic effect on the mango *Sclerotium*. According to Stevens(5) if antagonism occurs between fungous growths it indicates a difference between the strains. This antagonism does not appear when like strains are planted together in a culture dish. Nakata(3) states that "when aversion occurs it is to be concluded that the inocula in question are of different strains but when it does not, that they are of the same strain." From experiments to determine the relation of the mango *Sclerotium* to known strains of *S. delphinii* the writer found that the mango *Sclerotium* is a strain distinct from the four known races used for comparison. This conclusion is based on the fact that antagonism or aversion occurred when the mango *Sclerotium* was grown with different strains of *S. delphinii.*

TAXONOMY

In the foregoing morphological and cultural studies the mango *Sclerotium* appears to resemble more closely *S. delphinii* than *S. rolfsii.* The difference found between the mango *Sclerotium* and *S. rolfsii* seems sufficiently great to warrant the separation of the mango fungus from the latter species. The characters by which the mango organism may be readily separable from any of the strains of *S. rolfsii* used in these studies are summarized as follows: (*a*) Sclerotial production on agar media almost always began after four to five days in *S. rolfsii* and after eight to ten days in the mango *Sclerotium;* (*b*) the development of concave or flattened sclerotia and sclerotial bodies with hilum-like scars separates the mango fungus from *S. rolfsii,* which produces globose sclerotia; (*c*) pits on the sclerotia were distinct in the mango organism but were generally absent in *S. rolfsii;* (*d*) the production of conspicuously larger, more irregular, but less numerous sclerotia, Hay's brown or tawny in color, distinguished the mango *Sclerotium* from *S. rolfsii,* which developed small, numerous, and more uniform sclerotia of cinnamon brown color; (*e*) at 35° to 35.5° C. the cultures of *S. rolfsii* showed better development and production of sclerotia, while the mango *Sclerotium* showed arrested growth and no production of sclerotia.

There were also minor differences noted between the mango *Sclerotium* and *S. delphinii.* The mango fungus produced in general densely floccose mycelium, but the growth of *S. delphinii* was in the form of strands of white mycelium. *Sclerotium delphinii* began to produce sclerotia in plate cultures on agar media after four to five days, except in the case of *S. delphinii* III which produced them usually after six to seven days, but the mango *Sclerotium* produced these bodies only after eight to ten or more days. The sclerotia of *S. delphinii* are on the average larger than those of the mango *Sclerotium*, as shown in Table 4. However, there are certain media and conditions in which these differences in average size become less significant. Since the characters of the mango *Sclerotium* resemble more nearly those of *S. delphinii* than those of *S. rolfsii*, the writer refers the mango organism to *Sclerotium delphinii* Welch.

TABLE 4.—*Showing the average diameters of sclerotia of mango Sclerotium and S. delphinii strains on six agar media.*

Medium.	Mango *Sclerotium*.	*S. delphinii* W-517.	*S. delphinii* I.	*S. delphinii* II.	*S. delphinii* III.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*
Potato-glucose agar	2.2	2.4	2.3	2.8	2.6
Carrot-glucose agar	2.7	3.9	3.4	4.4	3.2
Oatmeal agar	2.2	3.2	2.9	3.9	2.9
Cornmeal agar	2.3	2.4	2.6	3.4	3.5
Saccharose-beef agar	1.7	1.8	2.0	1.9	1.8
Dextrose-beef agar	1.7	1.9	2.4	2.2	1.7

For purposes of verification, cultures of the mango fungus were sent to Dr. F. L. Stevens, of the University of Illinois, and in his letter dated October 27, 1932, to Dr. T. G. Fajardo, of the botany division of the Bureau of Science, he states, "I would incline to agree with Mr. Palo and refer the fungus to *S. delphinii.*"

PATHOGENICITY OF THE FUNGUS

Infection with the mycelium.—The shells of fresh mango seeds were removed and the seeds planted in pots containing moist soil that had been autoclaved for three hours at 15-pounds' pressure. After twelve to seventeen days the young plants all emerged and were immediately inoculated with the fungus from young plate culture on potato-glucose agar by placing a block of the agar, containing the mycelium, at the base of each plant. The mycelium developed rapidly and produced small sclerotia of more or less uniform size on the surface of the soil two or three days after inoculation, within which period nearly all the inoculated plants showed visible symptoms of infection. In some instances the dark brown lesion, which is the characteristic symptom of the disease in nature, was noticeable after twenty-four hours. Seventeen of the twenty inoculated plants died within twenty-three days after inoculation. Owing to the rapid development of the disease many of the inoculated plants did not show any marked change in the color of the leaves. As soon as the dark brown lesion appeared and the mycelium had grown around the base of the stem and caused the tissues of the young plants to shrivel, the leaves showed signs of wilting (Plate 10, fig. 2). Subsequently the affected plant drooped and died. A few of the wilted seedlings were dug up and these showed the sclerotia on the base of the stems and also on the cotyledons (Plate 11, fig. 2). The rest of the inoculated seedlings that remained alive showed at first the dark brown lesion at their bases but no further development of the disease was noted. These survived. All of the thirteen plants used as checks remained healthy.

Infection by burying the seed with sclerotia.—Fresh mango seeds from which the husk was removed, together with a few mature sclerotia obtained from a 20-day-old plate culture of the fungus on potato-glucose agar, were planted to a depth of 1 inch in sterilized soil. Ten pots were used, with one seed to a pot. Three other pots to which no sclerotia were added were used as checks. The seeds in all the control pots and in seven of the ten inoculated pots germinated after twelve to fifteen days. The seedlings in three of the inoculated pots died, and sclerotia were found at the base ten days after emergence. Two other inoculated plants showed the symptoms of the disease but continued to live. The remainder of the seedlings in the inoculated pots did not show any sign of infection. The seeds that did not germinate in the inoculated pots were dug up and examined. All were rotted, and several sclerotia adhered to the decayed cotyledons. The check plants remained healthy.

Infection by planting the seed in natural Sclerotium-infected soil.—A quantity of soil naturally infected with mango *Sclerotium* was obtained from one of the beds in which the disease occurred severely in Muntinlupa Plantation, Rizal Province. The soil contained mycelium and sclerotial bodies of the fungus. Five hundred grams of this soil were added to each of ten pots containing sterilized soil and then mixed thoroughly. A fresh mango seed with its husk removed was planted in each pot. The control consisted of four pots to which infected soil was not added. All the seeds germinated but only five of the newly emerged plants in the infected soil showed the disease. After a few more days three of the diseased seedlings showed signs of wilting and later died; the other two infected ones survived. The rest of the seedlings in the inoculated pots, as well as all of the control plants, remained disease-free.

In all of the above infection experiments the organism was recovered in reisolations made by plating out the sclerotia on potato-glucose agar. It may be noted in the above tests that the disease can readily be reproduced on mango seedlings by planting the seeds in soil naturally infected with *Sclerotium,* or by placing close to the seeds at time of planting, or close to the seedlings after their emergence, either mycelium or sclerotial bodies. The fungus under study showed pronounced virulence on young or newly emerged plants but it lost its power of killing the seedlings as soon as they developed harder tissues. Its potential parasitism has been proved on mango seedlings without inflicting injuries at points of inoculation.

INOCULATION OF VARIOUS PLANTS WITH THE MANGO SCLEROTIUM

The pathogenicity of the mango *Sclerotium* was tested on various plants by placing a square centimeter block of agar containing the mycelium of a young culture of the fungus at the base of each plant. As shown in Table 5 positive infection was obtained on nearly all the inoculated plants and in many cases the plants died of this infection. A marked virulence was shown by the fungus on mango (*Mangifera indica* L.), paayap [*Vigna sinensis* (L.) Savi], upo [*Lagenaria leucantha* (Duch.) Rusby], patola [*Luffa acutangula* (L.) Roxb.], squash (*Cucurbita maxima* Duch.), pepper (*Capsicum annuum* L.), eggplant (*Solanum melongena* L.), radish (*Raphanus sativus* L.), and cabbage (*Brassica oleracea* L.).

The other crops were also found susceptible but they were attacked less severely by the fungus. Frequently the infected plants that continued to live showed cavities or shriveled-up tissues at points where the fungus first became established. The period of incubation, in most cases, ranged from one to four days. It seems possible that the hosts, which were attacked severely by the mango fungus in inoculation experiments in the greenhouse, will also become infected under natural conditions and will therefore serve as agents in harboring the pathogene. Since the above experiments were not conducted extensively with other hosts, further observation and experiments may increase the number of plants known to be affected by the fungus.

TABLE 5.—*Showing the results of inoculating various plants with mango Sclerotium ten days after inoculation.*

Common name of plant.	Botanical name.	Age of plants.	Plants used.		Plants infected.		Plants killed.	
			Inoculated.	Check.	Inoculated.	Check.	Inoculated.	Check.
		Days.						
Ampalaya	*Momordica charantia* L.	25	6	4	6	0	0	0
Bean	*Phaseolus vulgaris* L.	15	6	5	6	0	0	0
Cabbage	*Brassica oleracea* L. var. *capitata* L	30	6	6	6	0	6	0
Carrot	*Daucus carota* L.	30	5	4	3	0	3	0
Corn	*Zea mays* L.	15	7	6	2	0	0	0
Cucumber	*Cucumis sativus* L.	29	6	5	6	0	3	0
Eggplant	*Solanum melongena* L.	30	6	4	6	0	6	0
Garlic	*Allium sativum* L.	32	5	5	5	0	0	0
Mandarin orange	*Citrus nobilis* var. *deliciosa* Swingle	31	18	15	8	0	6	0
Mungo	*Phaseolus radiatus* L.	15	10	13	10	0	10	0
Mustard	*Brassica integrifolia* (West) O. E. Schulz	35	4	3	4	0	2	0
Onion	*Allium cepa* L.	32	5	5	5	0	3	0
Paayap	*Vigna sinensis* (L.) Savi	15	13	12	13	0	3	0
Papaya	*Carica papaya* L.	35	4	4	4	0	1	0
Patola	*Luffa acutangula* (L.) Roxb	15	6	7	6	0	3	0
Peanut	*Arachis hypogaea* L.	20	9	7	4	0	0	0
Pepper	*Capsicum annuum* L.	35	4	4	2	0	2	0
Radish	*Raphanus sativus* L	35	4	3	4	0	4	0
Rice	*Oryza sativa* L.	30	25	30	20	0	0	0
Sitao	*Vigna sesquipedalis* Fruw	15	3	2	3	0	0	0
Squash	*Cucurbita maxima* Duch	15	4	4	4	0	2	0
Sweet potato	*Ipomoea batatas* (L.) Poir	32	6	4	1	0	0	0
Tomato	*Lycopersicum esculentum* Mill	35	20	35	20	0	20	0
Upo	*Lagenaria leucantha* (Duch.) Rusby	15	5	7	5	0	3	0

A COMPARISON OF THE INFECTIVE CAPACITY OF THE MANGO SCLEROTIUM AND SCLEROTIUM ROLFSII FROM PEPPER, RICE, AND TOMATO

Young seedlings of mango (*Mangifera indica* L.), papaya (*Carica papaya* L.), cabbage (*Brassica oleracea* L. var. *capitata* L.), radish (*Raphanus sativus* L.), tomato [*Lycopersicum esculentum* Mill.), mustard [*Brassica integrifolia* (West) O. E. Schulz.], ampalaya (*Momordica charantia* L.), and rice (*Oryza sativa* L.) were inoculated under identical conditions with the mango *Sclerotium*, and with *S. rolfsii* from pepper, rice, and tomato in separate pots. Infection was obtained on all hosts inoculated with each of the strains, and the disease progressed with almost equal severity on those hosts. From this limited trial it was found that under conditions used in artificial experiments the mango organism is as aggressive as *S. rolfsii*.

SEASONAL DEVELOPMENT

The *Sclerotium* disease on mango seedlings occurred in the nursery in Muntinlupa Plantation, Rizal Province, from June to October, 1931; it was especially prevalent in July and August when the precipitation was rather heavy and when the seedlings were still young and in their most susceptible stage. Since mango seeds can hardly be kept viable for more than a week, they are planted while still fresh; and since they can be obtained in greater abundance in June and July than in other months, planting usually takes place in these months, during which the conditions are favorable for the development of the disease. In the presence of conditions favorable for infection, the seeds planted in beds containing the fungus would produce some seedlings that would show the disease. Moisture is undoubtedly the most important factor influencing development of the fungus in seedbeds, so in months of heavy precipitation the disease is prevalent. Under moist conditions the fungus is capable of living as a saprophyte in the soil. In October and November, 1931, the disease was found also on a few mature seedlings left in the nursery, but its development was so slow that it did not affect them seriously. In December, 1931, and January, 1932, certain parts of the beds were overcome by the thick growth of grasses and weeds, which kept the soil beneath them always more or less moist, thus supplying favorable conditions for the growth and survival of the fungus. During the dry months (January to April) the fungus seems to be less destructive, especially if the temperature is rather high.

VIABILITY OF THE SCLEROTIA

That the fungus can live over an unfavorable season and then develop by means of sclerotia is evidenced by the following test: A quantity of soil with an abundance of sclerotia was air-dried and then kept in a Petri dish at room temperature. From time to time some sclerotia were picked out with flamed forceps, washed with several changes of sterile water, and plated out on potato-glucose agar. Growth was readily obtained after six months, and after thirteen months a few of the sclerotia were still alive. That soils saturated with water do not seem to affect the germination of sclerotia and the virulence of the fungus much was shown by the following test: Each of nine pots containing sterile soil was planted with a husked, clean, fresh mango seed. After the emergence of the seedlings, six pots were inoculated with mature sclerotia, and the other pots were used as checks. All of the pots were placed in a shallow, rectangular, galvanized-iron pan filled with water. The top layer of the soil in the pots was kept always very moist. Sclerotia germinated on the surface of the soil after six to eight days and later caused a severe infection in the mango seedlings. From this test it seems probable that under moist conditions of the soil in the nursery the fungus will live indefinitely, especially if susceptible hosts are present.

DISCUSSION AND SUGGESTIONS FOR CONTROL

In the absence of experiments on the control of the *Sclerotium* causing seed rot and seedling stem rot of mango in the nursery the following may be suggested:

1. *Sanitary measures.*—Strict sanitation, if practiced, will reduce to a great extent the destruction caused by the disease, since the sclerotia are not as numerous as spores and are not adapted to wind dissemination. The soils infected by the fungus should be thoroughly surface-burned before the seedbeds are prepared. This process will kill all the plant pathogenic organisms hibernating or growing saprophytically in the soil. In places where combustible materials are readily available it can be done with little expense. Infected mango seedlings and weeds should be pulled up and burned.

2. *Cultural methods.*—As the fungus is a moisture-loving organism, there should be no excessive use of water or close planting. The latter is conducive to poor aëration, tends to increase the humidity, and induces the rapid spread of the fungus from plant to plant. The seedbeds should be provided with

ample drainage, and it is advisable to prepare them in a place that is not too shady. In the nursery in Muntinlupa Plantation it was noted that the beds exposed to from two-thirds to three-fourths sunlight showed very light *Sclerotium* infection and those exposed to from one-third to one-fourth sunlight showed severe infection. Adequate facilities for draining the nursery during the rainy periods should be provided in order to avoid the spread of the fungus, which may be carried by water from one place to another.

3. *Chemical treatment.*—White(11) states that the control of root rot and crown rot of *Delphinium* caused by *S. delphinii* may be effected by removing all badly diseased plants and drenching the surrounding soil with corrosive sublimate (1: 2,000). When all the beds are heavily contaminated, susceptible hosts should not be planted for a number of years, or the soil should be changed to a depth of 8 or 10 inches. These control measures may be tried for *S. delphinii* causing seedling stem rot and seed rot of mango.

SUMMARY

1. A species of *Sclerotium,* which causes seed rot and seedling stem rot of mango, occurred in the nursery in Muntinlupa Plantation, Rizal Province, and is reported for the first time in the Philippines. Ten per cent of the mango seedlings in the nursery died of stem rot and many of the seeds rotted before or during germination, owing to the attack of the fungus.

2. The characteristic symptom of stem rot is the presence of white mycelium and sclerotial bodies of the causal fungus on the base of the stems of infected seedlings. Beneath, or a little in advance of, the growing mycelium, a blackish brown lesion develops. After the mycelium has completely encircled the stem, the leaves wilt and the seedling dies.

3. The seeds attacked by the fungus completely rot before or during germination. Numerous sclerotia develop on the cotyledons of the rotted seeds.

4. A comparative study of *Sclerotium* isolated from mango *S. rolfsii* and *S. delphinii,* in plate cultures, on various media and at different temperatures, showed that the mango *Sclerotium* resembles more closely *S. delphinii* than *S. rolfsii;* hence, the organism is referred to in this paper as a strain of *S. delphinii.*

5. The pathogenicity of the fungus has been proved on mango seedlings when inoculations were made with the mycelium and sclerotia of the fungus or when the seeds were planted in infected soil.

6. The fungus is capable of attacking various unrelated hosts, as shown by infection experiments performed in the greenhouse.

7. The fungus passes over adverse conditions by means of sclerotial bodies. The sclerotia kept in dry conditions remained alive for more than a year.

8. The disease may be controlled by strict sanitation and by proper cultural methods.

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ILLUSTRATIONS

PLATE 1

FIG. 1. Mango seedlings showing the symptoms of wilting due to stem rot caused by *Sclerotium*. Note the mycelium and sclerotia on the base of the stems. About × 0.4.

2. Healthy seedlings. About × 0.4.

PLATE 2

FIG. 1. Seed rot of mango due to *Sclerotium*. × 1.25.

2. A mango seedling killed by *Sclerotium*, showing the mycelium and sclerotia on the cotyledons.

3. A germinating mango seed which rotted due to *Sclerotium*, showing sclerotia of the causal fungus on the rotting cotyledons.

PLATE 3

FIG. 1. A portion of a mycelial strand of the mango *Sclerotium* obtained from 6-day-old plate culture on potato-glucose agar. × 533.

2. A portion of a mycelial strand consisting of pinkish cinnamon barrel-shaped cells obtained from a 30-day-old plate culture on dextrose-beef agar. × 533.

3. Clamp connections on the main hyphæ of the mango *Sclerotium* in a 6-day-old plate culture on potato-glucose agar. × 533.

4. Short sclerotiumlike cells obtained from a 30-day-old plate culture on dextrose-beef agar. × 533.

5. Lobulate hyphæ in a 30-day-old plate culture on dextrose-beef agar. × 533.

6. A section of a large compound sclerotial body obtained from a 37-day-old plate culture on steamed oatmeal, showing smaller hyphal cells which are loosely interlaced. × 533.

7. A section of a mature sclerotial body from a 56-day-old plate culture on potato-glucose agar, showing the larger pseudoparenchyma cells beneath a boundary of a colored layer of cells. × 533. (The drawings on Plate 3 were made with the aid of a camera lucida.)

PLATE 4

FIG. 1. A portion of a plate culture of the mango *Sclerotium* on potato-glucose agar, showing maturing sclerotia with liquid exudate and also white tufts of hyphæ from which the stalk-bearing sclerotia arise. × 3.3.

2. A 35-day-old plate culture of the mango *Sclerotium* on potato-glucose agar, showing the distribution of sclerotia and pits on the larger sclerotia. About × 1.2.

PLATE 5

FIGS. 1 to 4. Sclerotia of the mango *Sclerotium.*

1. Ventral sides of sclerotia, showing hilumlike scars. × 3.3.
2. Ventral sides of sclerotia, showing concavities. × 3.3.
3. Dorsal view of sclerotia, markedly showing the pits × 3.3.
4. Composite sclerotia produced on steamed oatmeal, showing pits and spongelike appearance. × 1.5.

FIGS. 5 to 12. Sclerotia produced by eight races of *Sclerotium* on potato-glucose agar.

5. *Sclerotium delphinii* W–517.
6. *Sclerotium delphinii* I.
7. *Sclerotium delphinii* II.
8. *Sclerotium delphinii* III.
9. Mango *Sclerotium.*
10. *Sclerotium rolfsii* from pepper.
11. *Sclerotium rolfsii* from rice.
12. *Sclerotium* rolfsii from tomato.

PLATE 6

Seven-day-old plate cultures of three races of *Sclerotium* on potato-glucose agar. Slightly more than one-third natural size. Figs. 1, 5, and 9, at 35° to 35.5° C.; figs. 2, 6, and 10, at 28° to 32° C. (room temperature); figs. 3, 7, and 11, at 19° to 20° C.; and figs. 4, 8, and 12, at 6° to 8° C.

FIGS. 1 to 4. *Sclerotium rolfsii.*
5 to 8. Mango *Sclerotium.*
9 to 12. *Sclerotium delphinii* I.

PLATE 7

Twenty-day-old plate cultures on potato-glucose agar of six races of *Sclerotium* at 19° to 20° C.

FIG. 1. *Sclerotium rolfsii* on rice.
2. Mango *Sclerotium.*
3. *Sclerotium delphinii* W–517.
4. *Sclerotium delphinii* I.
5. *Sclerotium delphinii* II.
6. *Sclerotium delphinii* III.

PLATE 8

Showing antagonism between cultures of mango *Sclerotium* and *S. rolfsii* and also between cultures of *S. rolfsii* in plates of potato-glucose agar. Slightly more than five-ninths natural size.

FIG. 1. Mango *Sclerotium* (M) and *S. rolfsii* on pepper (P).
2. Mango *Sclerotium* (M) and *S. rolfsii* on rice (R).
3. Mango *Sclerotium* (M) and *S. rolfsii* on tomato (T).
4. *Sclerotium rolfsii* on pepper (P) and *S. rolfsii* on rice (R).
5. *Sclerotium rolfsii* on pepper (P) and *S. rolfsii* on tomato (T).
6. *Sclerotium rolfsii* on rice (R) and *S. rolfsii* on tomato (T).

PLATE 9

Showing antagonism of colonies of mango *Sclerotium* and *S. delphinii* strains in plates of corn-meal agar. Slightly more than five-ninths natural size.

FIG. 1. *a*, Mango *Sclerotium; b, S. delphinii* W–517.
2. *a*, Mango *Sclerotium; b, S. delphinii* I.
3. *a*, Mango *Sclerotium; b, S. delphinii* II.
4. *a*, Mango *Sclerotium; b, S. delphinii* III.

PLATE 10

FIG. 1. A healthy mango seedling (check).
2. Two diseased mango seedlings, showing wilted tops ten days after inoculation with *Sclerotium*. Nearly one-third natural size.

PLATE 11

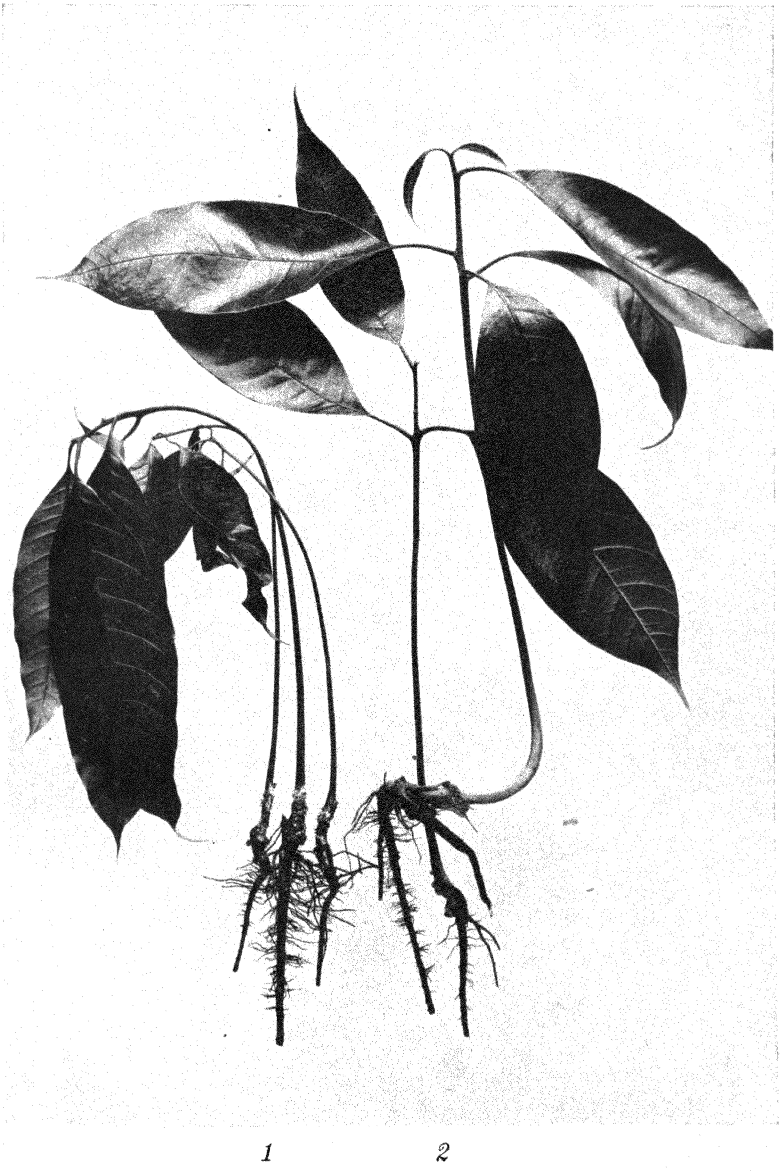
FIG. 1. A healthy mango seedling (check). About × 0.4.
2. A wilted mango seedling dug up from one of the pots inoculated with *Sclerotium*, showing the rotted endosperms and mycelium and sclerotia of the fungus on the base of the stem. About × 0.4.

PLATE 12

A pot of diseased seedlings twelve days after inoculation with the mango *Sclerotium*, showing sclerotial production on the diseased tissues and along the mycelial strands. More than × 0.5.

TEXT FIGURE

FIG. 1. Graphs showing sclerotial size of six strains of *Sclerotium* obtained from plate cultures on potato-glucose agar. *a, Sclerotium rolfsii* on rice; *b, Sclerotium* on mango; *c, Sclerotium delphinii* W–517; *d, Sclerotium delphinii* I; *e, Sclerotium delphinii* II; *f, Sclerotium delphinii* III.



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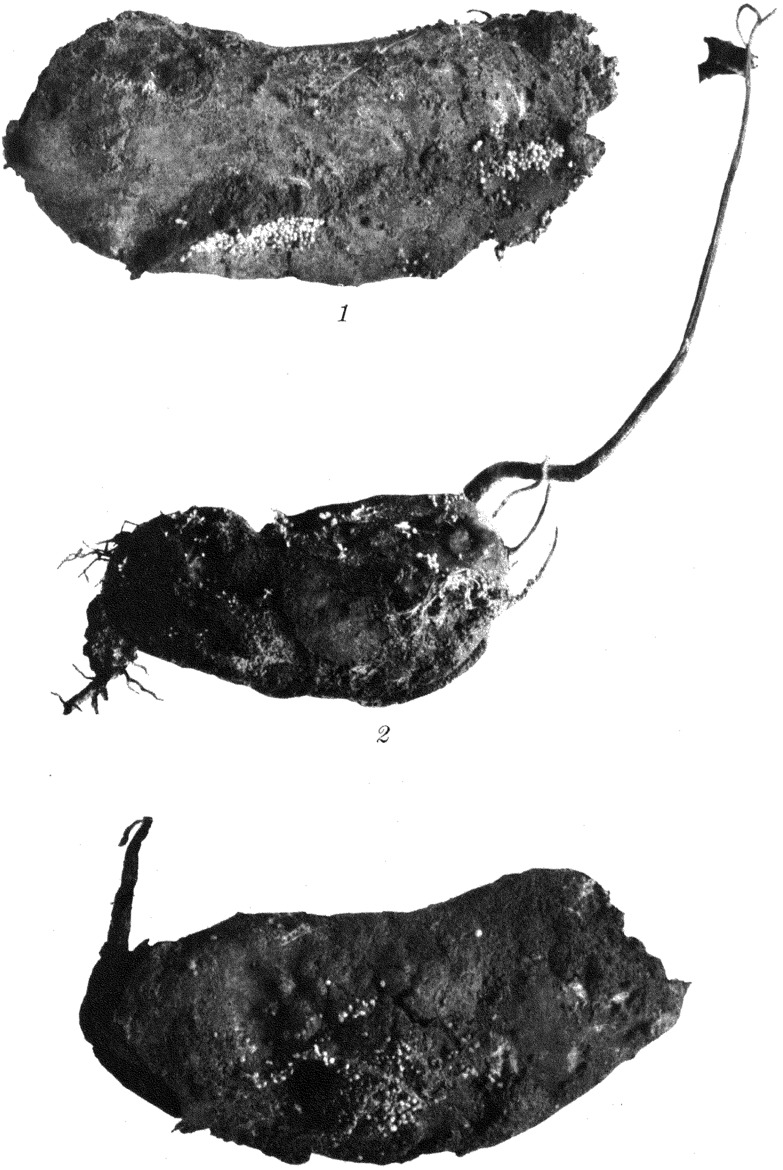

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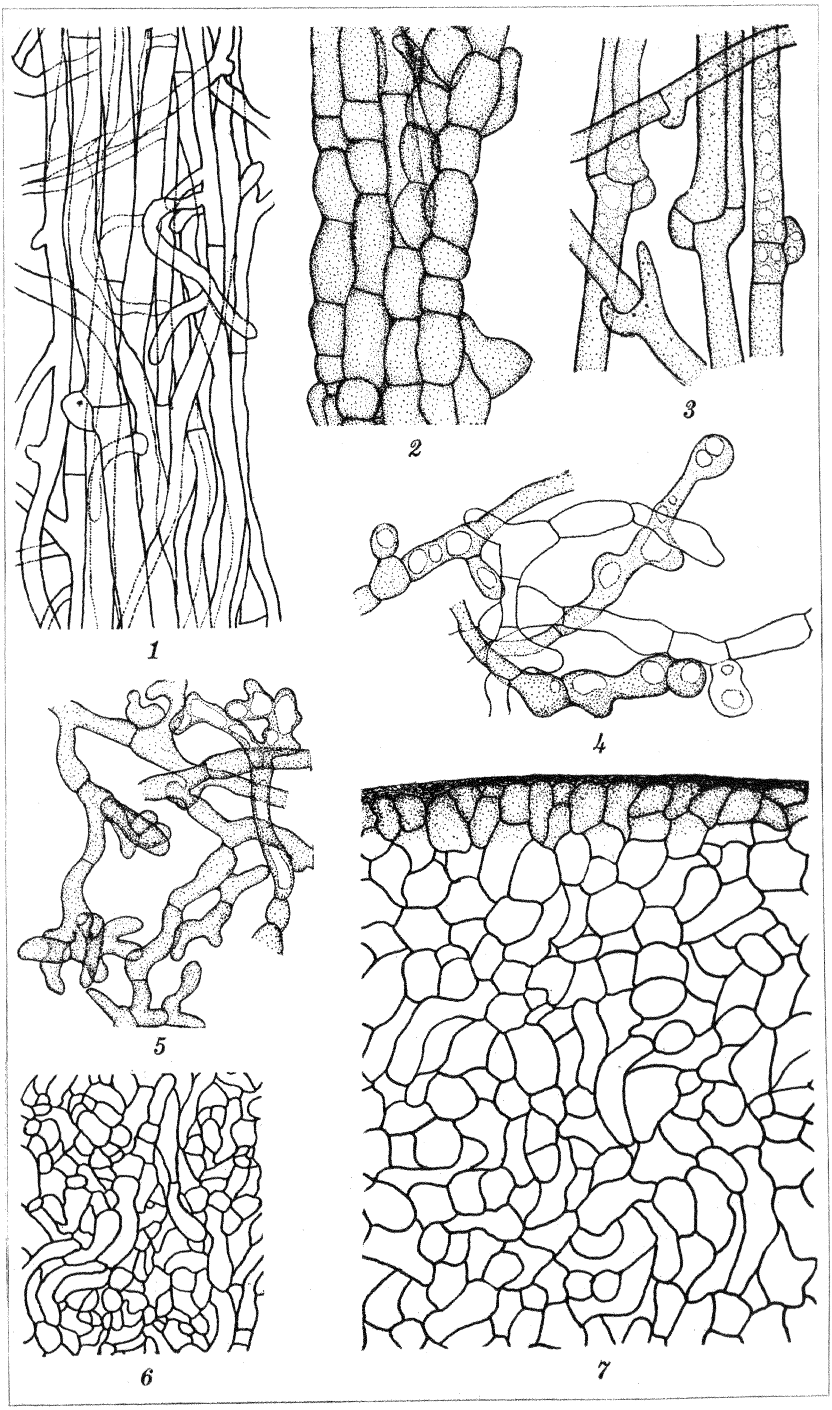

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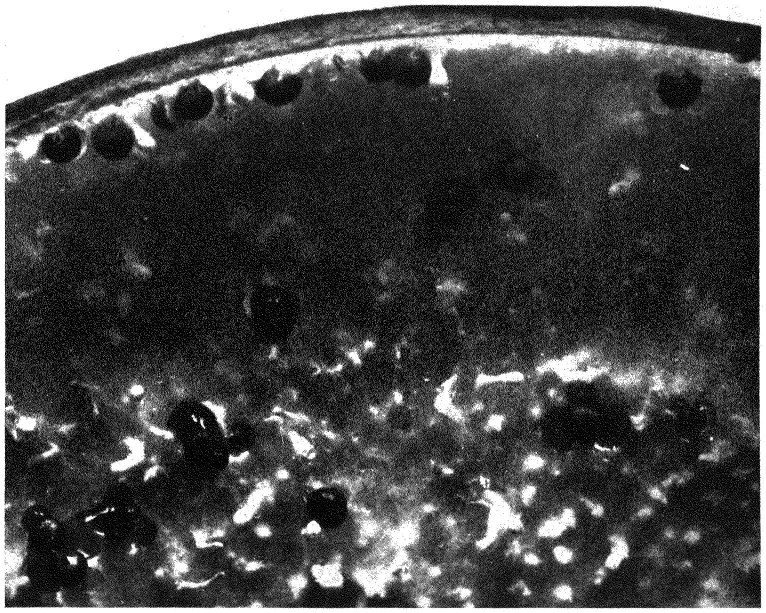

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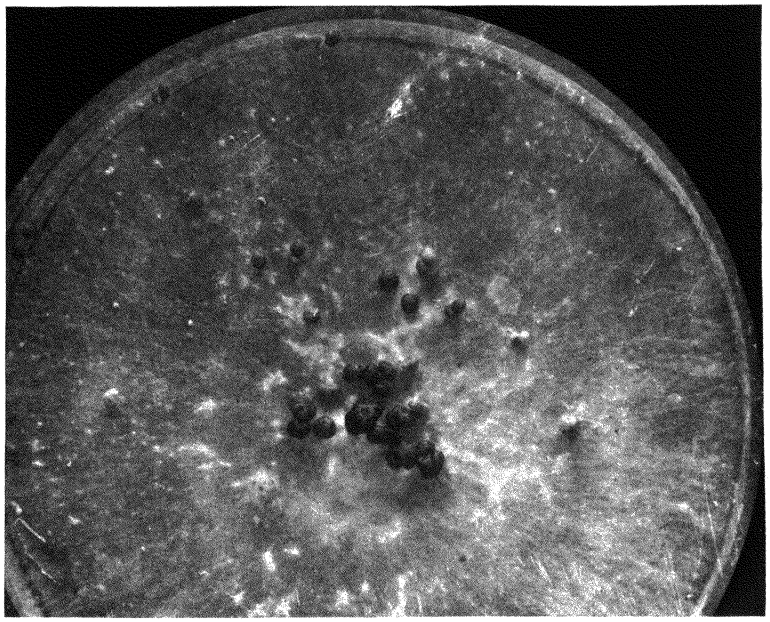

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PLATE 4.

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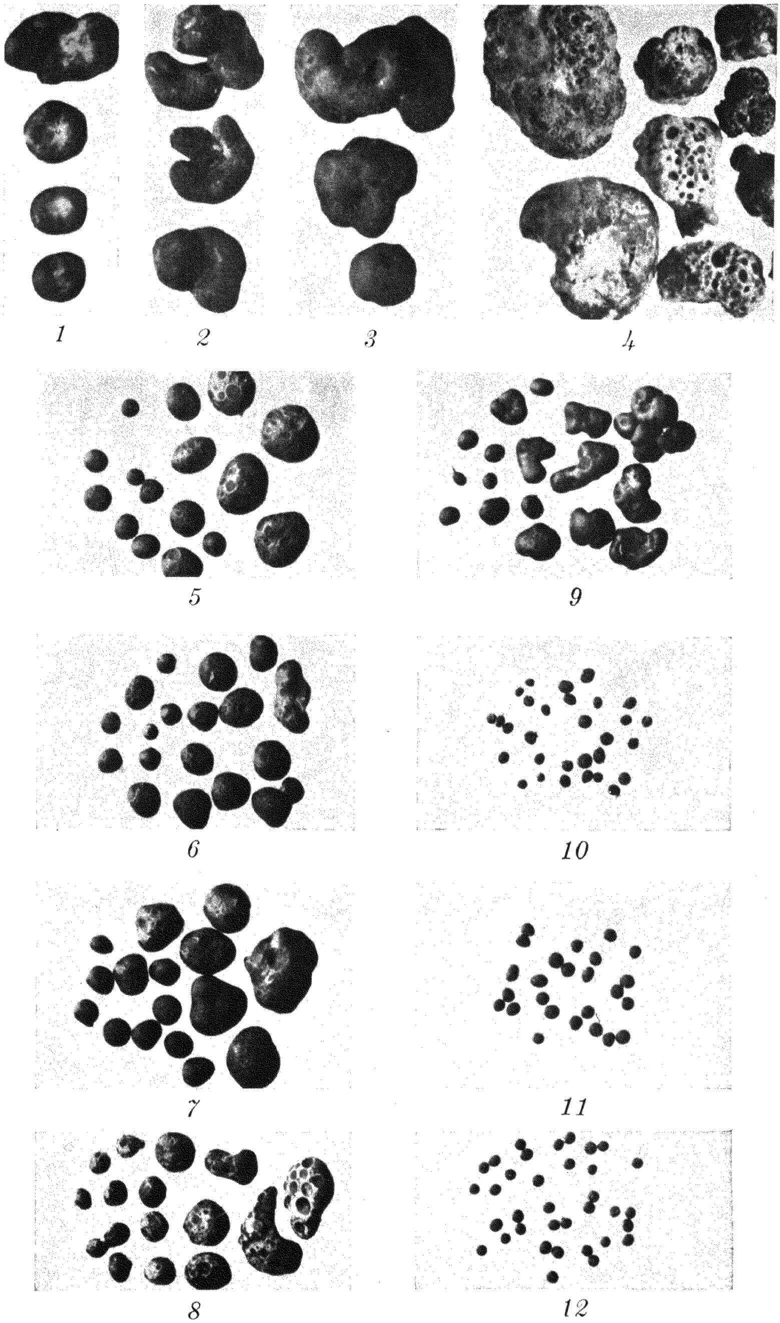

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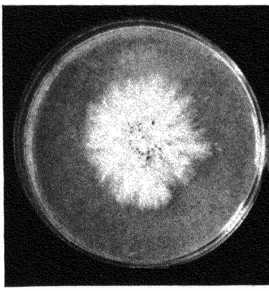

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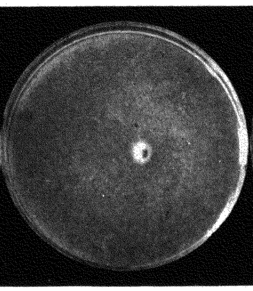

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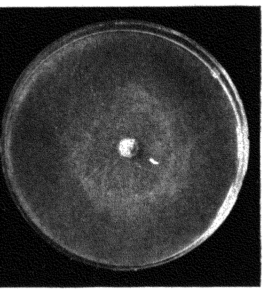

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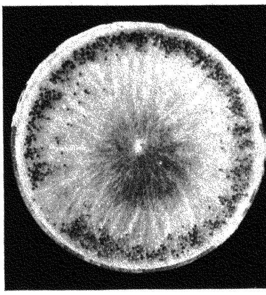

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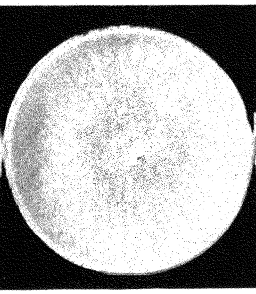

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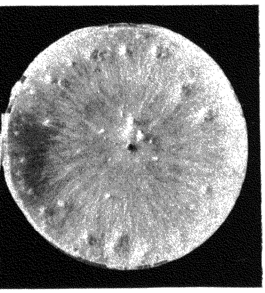

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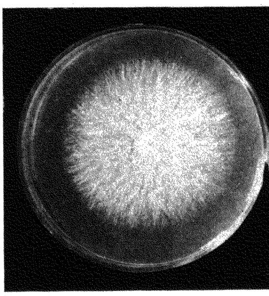

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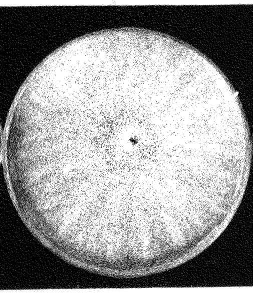

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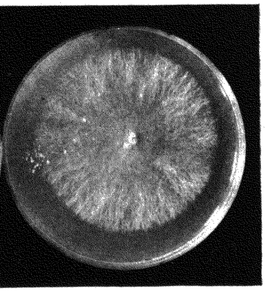

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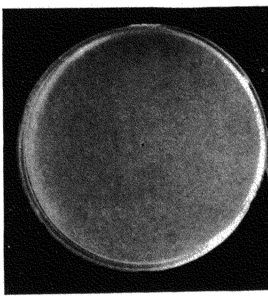

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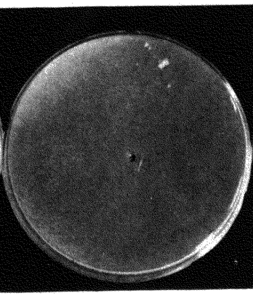

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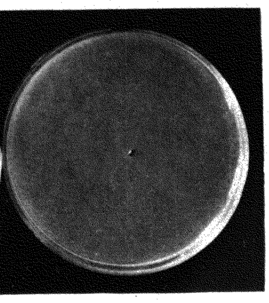

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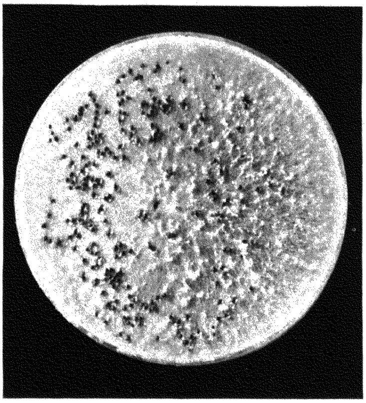
PLATE 6



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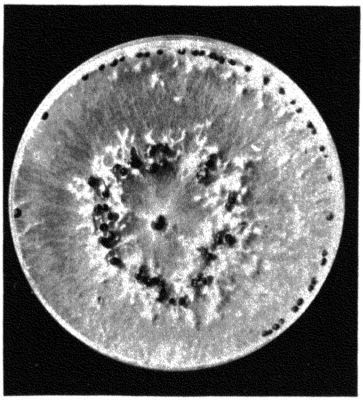

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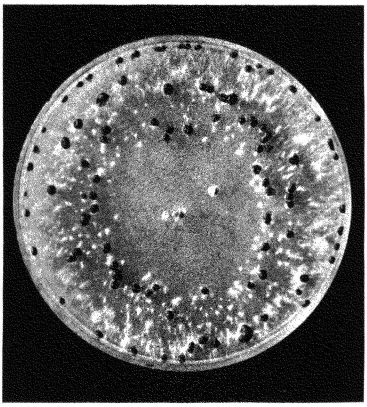

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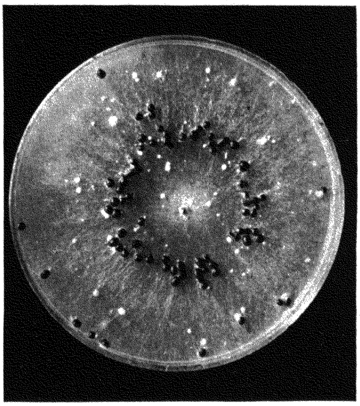

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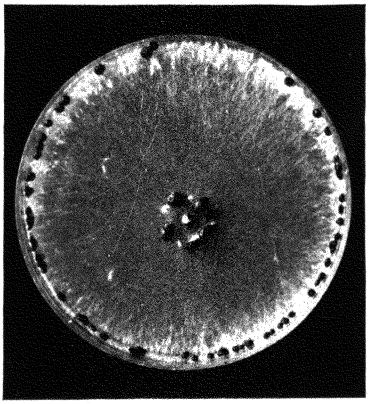

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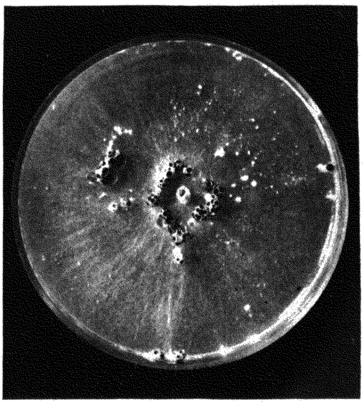

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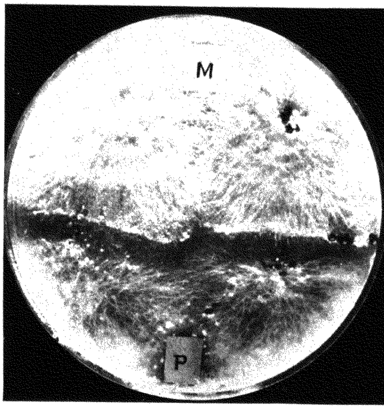
PLATE 7.



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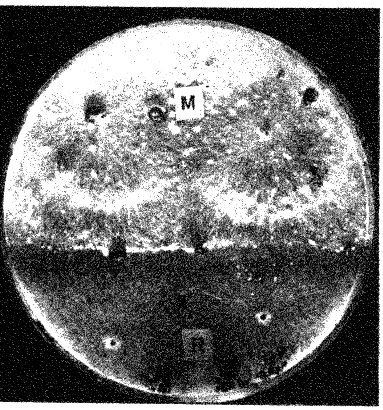

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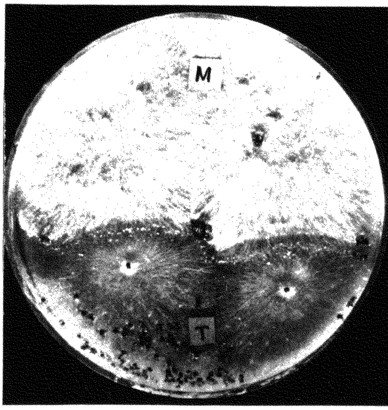

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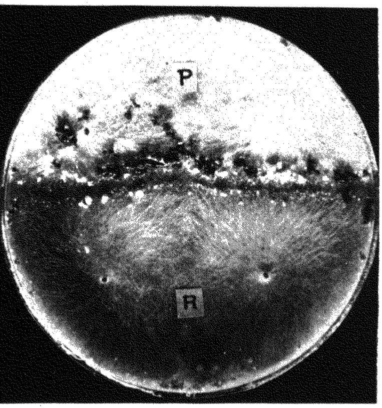

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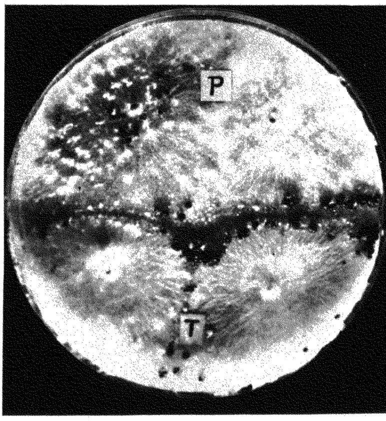

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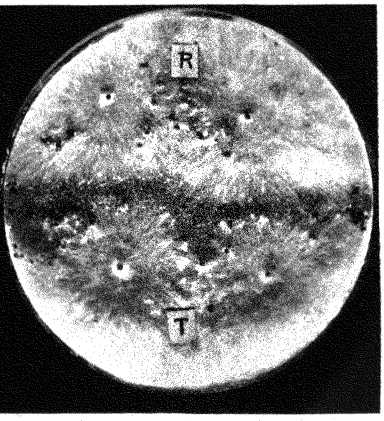

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PLATE 8.

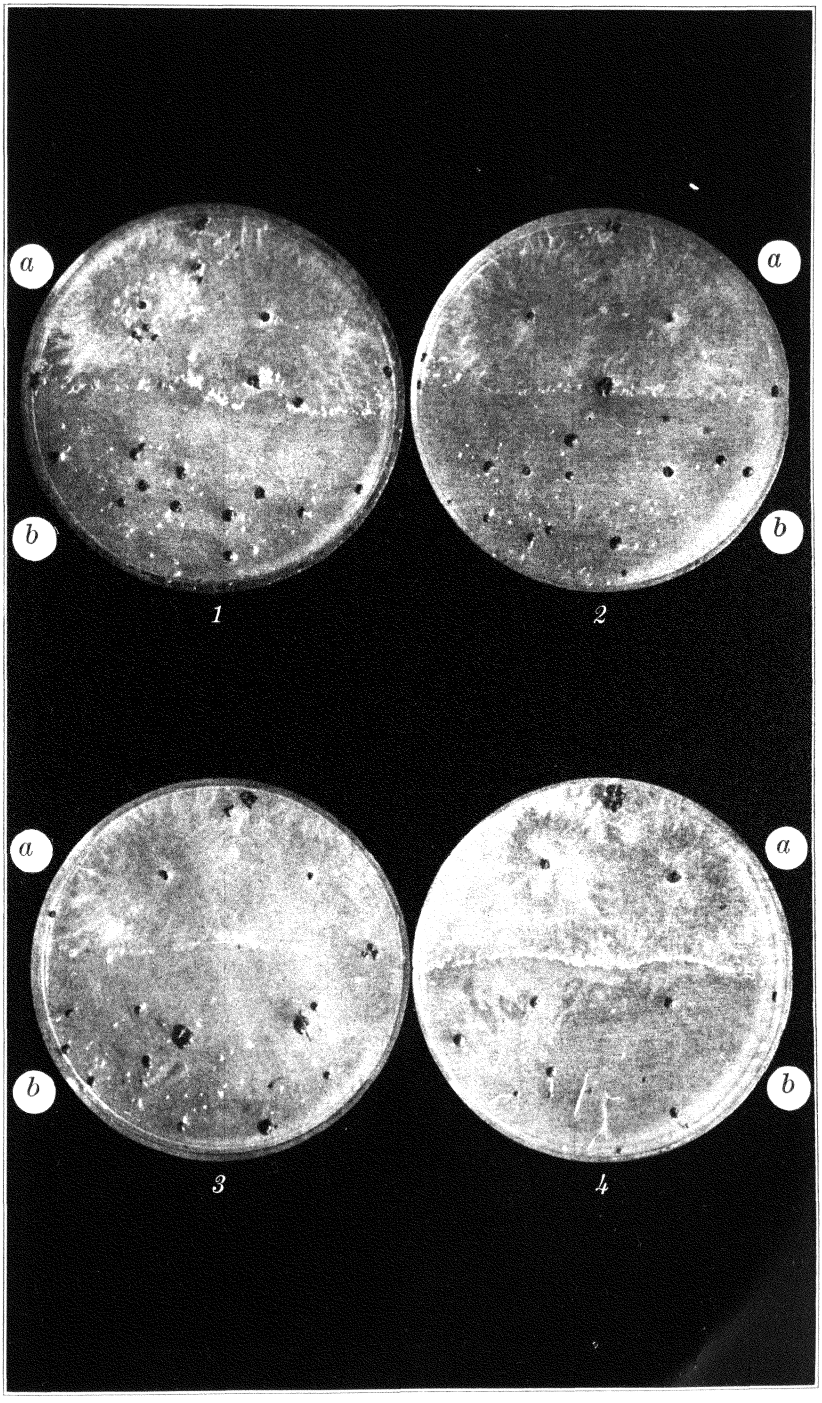
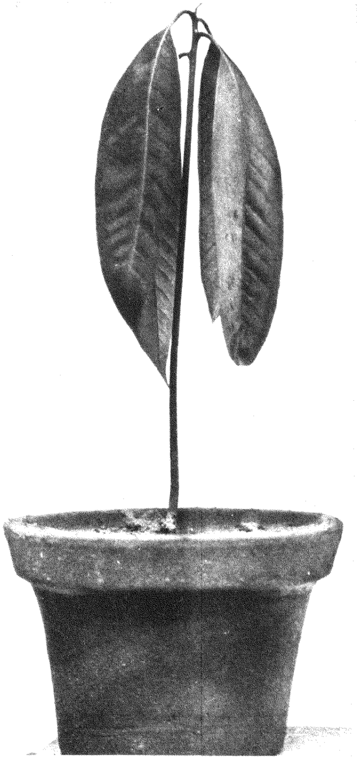


PLATE 9.

UNIV. OF MICH.



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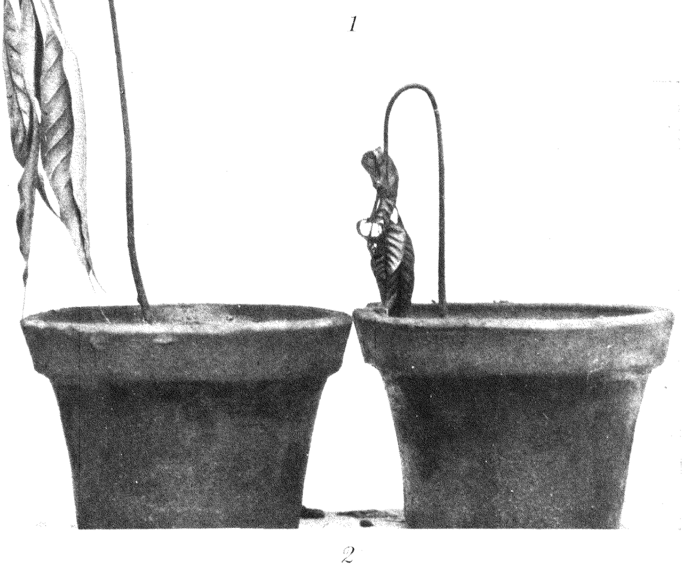

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PLATE 10.

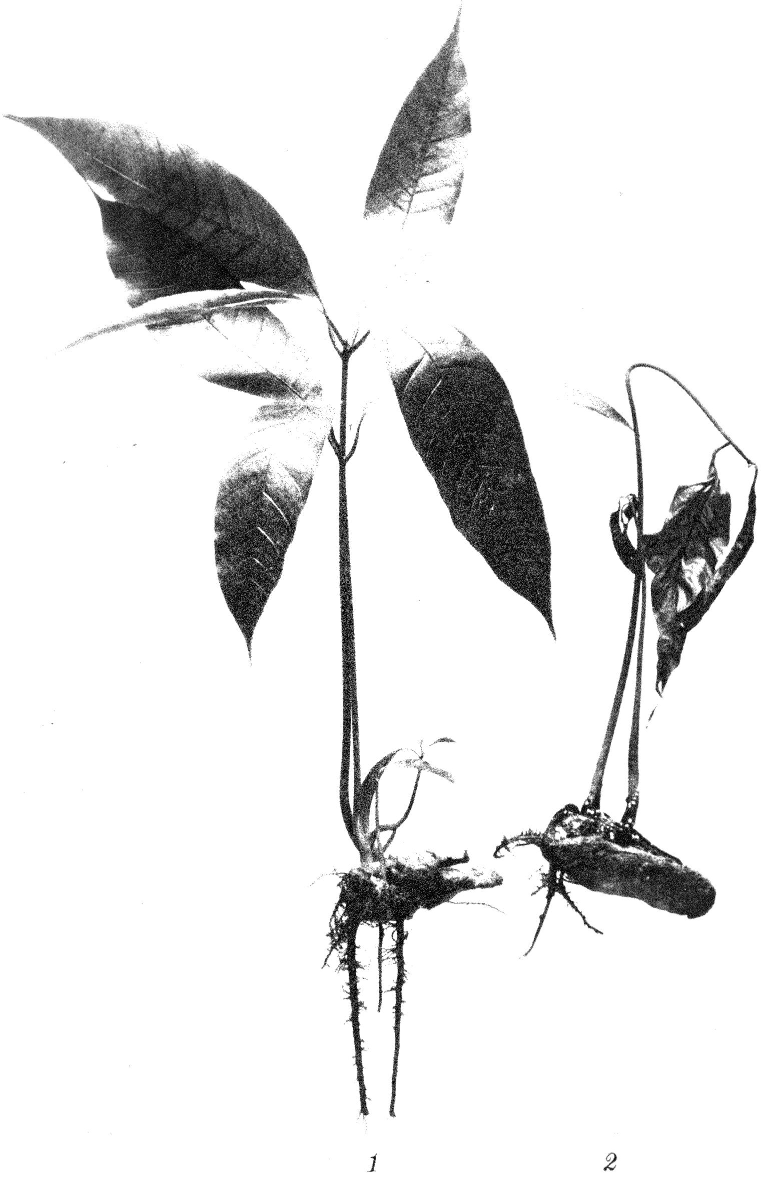

PLATE 11.

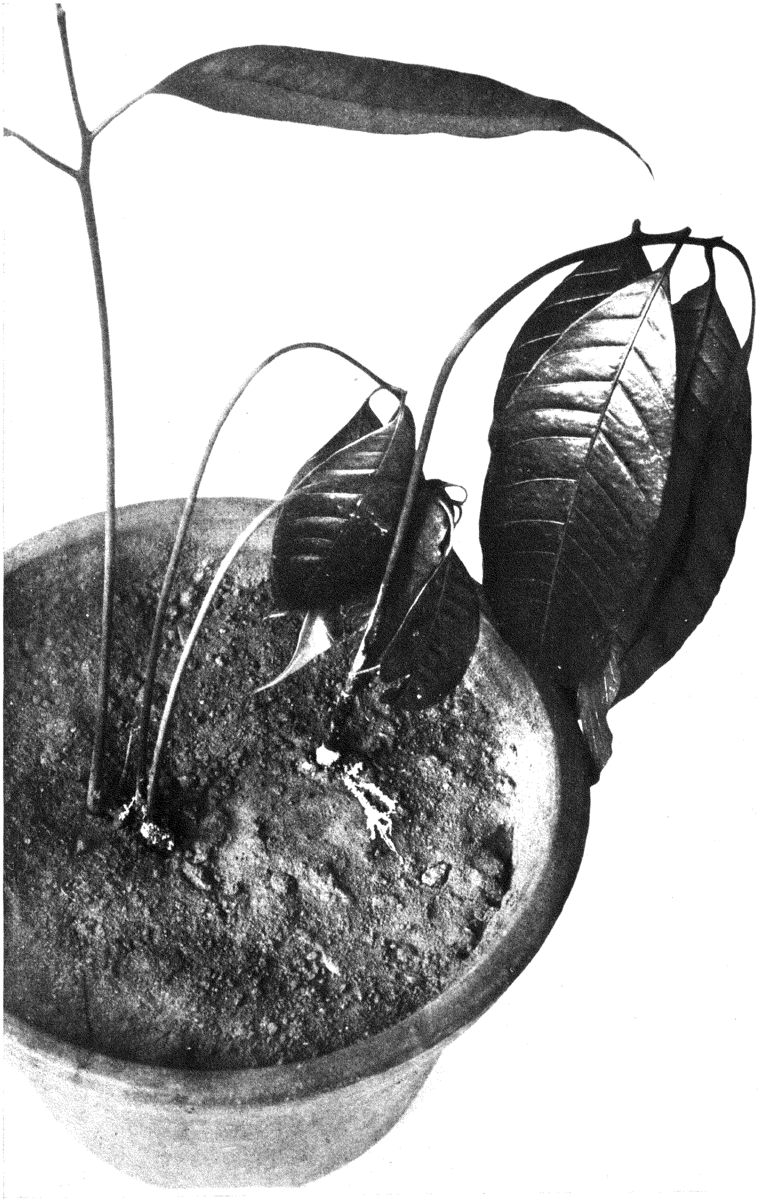

PLATE 12.

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COLOBOT ESSENTIAL OIL FROM CITRUS HYSTRIX DC. VAR. TOROSA

By **Simeona Santiago Tanchico** and **Augustus P. West**

Of the Bureau of Science, Manila

ONE PLATE

Numerous varieties of citrus fruits are grown in the Philippines, and a very good account of their cultivation is given by Wester.[1] Since the growing conditions in the Philippines are well adapted to citriculture it would seem that the cultivation of high-quality citrus fruits, merely for local consumption, could be developed into a profitable industry. Scientific citriculture on a commercial scale, in plantations, was recommended by Wester twenty years ago but, as shown by the data recorded in Table 1, considerable quantities of fruits are still imported into the Philippines.

TABLE 1.—*Citrus fruits imported into the Philippines in 1931.*[a]

Kind of fruit.	Quantity.	Value.
	Kilos.	*Pesos.*
Lemon	293,415	108,725
Orange	2,714,041	742,001
Pomelo	513,957	56,221
Total	3,521,413	906,947

[a] Annual Report of Insular Collector of Customs (1932) 145.

Various investigations have been made of the citrus fruits grown in the Philippines. The juices of these fruits contain vitamins and are used not only as a beverage but also for medicinal purposes. Gibbs and Agcaoili[2] investigated the possibilities of bottling Philippine orange and lime juices. They found that juices containing 15 per cent sugar kept well and had a good flavor after two years of storage. They also obtained good results with fermented orange juice.

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[1] Philip. Bur. Agr. Bull. 27 (1913); Philip. Agr. Rev. 8 (1915) 5.

[2] Philip. Journ. Sci. § A 7 (1912) 403.

Dovey [3] made paper from the pulp of Philippine oranges.

Wells, Agcaoili, and Orosa [4] analyzed the juices of a number of varieties of Philippine citrus fruits and also determined the yield of essential oil obtained from the peel.

Miss Orosa in her popular bulletin [5] gives directions for making jams, marmalades, preserves, and pastes from citrus fruits.

Brooks [6] examined the essential oil obtained from the rind of green Philippine oranges (naranjita) and found that the odor was just as fine as that given by imported orange-peel oil.

Recently, we purchased in one of the local markets a quantity of citrus fruits known locally as colobot. Examination of the essential oil obtained from the peel of this fruit showed that the oil had a very refined odor and appeared to be a perfumery product of good quality.

EXPERIMENTAL PROCEDURE AND RESULTS

The fruit known locally as colobot was identified by Dr. E. Quisumbing, of the Bureau of Science, as *Citrus hystrix* DC. var. *torosa* (Blanco) Wester. A description of these fruits is given by Wester.[7] The colobot is a spiny tree which attains a height of 6 or more meters. The fruits we examined had a transverse diameter ranging from 3.5 to 4 centimeters for the small fruits and 5 to 5.5 centimeters for the larger fruits. These fruits grow wild in Batangas Province and are also cultivated to some extent, as they have at present a sale value, in Manila markets, of 1 centavo each.

In some parts of the Philippines the crushed colobot fruits are mixed with gogo (pounded stems of *Entada phaseoloides*) and used as shampoo for cleaning the hair. The crushed rind of the fruit is also added to coconut oil to give it fragrance when applied to the hair.

The average proportions of the different parts of whole colobot fruits are given in Table 2.

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[3] Philip. Journ. Sci. § A 7 (1912) 411.

[4] Philip. Journ. Sci. 28 (1925) 453.

[5] Philip. Bu. Sci. Pop. Bull. 1 (1926).

[6] Philip. Journ. Sci. § A 6 (1911) 346.

[7] Philip. Agr. Rev. 8 (1915) 19.

TABLE 2.—*Proportions of the different parts of whole colobot fruits.*

Part of fruit.	Per cent.
Rind	40.79
Pulp and seeds	48.80
Juice	10.41
Essential oil [a]	0.88
Essential oil [a] (in rind alone)	2.15

[a] Essential oil obtained by steam distilling.

The acidity of the juice, calculated as citric acid, was found to be 6.39 per cent.

The essential oil contained in the rind of the colobot fruits was obtained in the following manner: The peel was removed from the fruits, crushed in a grinder, and steam-distilled. The oil, which floated on top of the distillate, was then separated and dried with calcium chloride. The yield of oil was found to be 2.15 per cent, which is rather high for a natural perfumery product. The essential oil, thus obtained by distillation, had a very fragrant and refreshing (limelike) fruity odor and was found to be of better quality than the oil extracted from the rind with alcohol. This oil should serve as a useful constituent for making perfume bouquets.

The yield of essential oil obtained from the rind of these fruits varied somewhat depending upon the size and age of the fruits. Fresh firm fruits with a rind of deep green color gave the highest yield of oil, while the old withered fruits with a yellow rind gave a comparatively small yield. The large green (mature) fruits yielded considerably more essential (peel) oil than the smaller and younger fruits and the odor of the oil was also somewhat finer.

The constants of colobot oil were determined and the data are recorded in Table 3.

TABLE 3.—*Physical and chemical constants of colobot-peel oil.*

Specific gravity ($d \frac{30^\circ}{4^\circ}$ C.)	0.8506
Specific rotation ($A \frac{30^\circ \text{ C.}}{\text{D}}$), degrees	+ 26.59
Refractive index ($N \frac{30^\circ \text{ C.}}{\text{D}}$)	1.4665
Acid value	0.93
Saponification value	11.4

When distilled the essential oil from the peel of colobot fruit gave the results recorded in Table 4.

TABLE 4.—*Distillation of colobot-peel essential oil. (Amount of oil distilled, 100 cubic centimeters.)*

Fraction.		Amount obtained.
No.	Temperature.	
	°C.	cc.
1	Below 160	2.0
2	160–166	4.5
3	166–170	19.0
4	170–172	23.5
5	172–175	12.0
6	175–180	16.0
7 (residue)		21.0

Various tests were made to determine the characteristics of colobot-peel oil.

The oil decolorized a dilute solution of potassium permanganate and also bromine water indicating the presence of double-bond compounds in the oil.

The oil gave very decided tests for aldehydes as follows:

A red color with Schiff's reagent within a time limit of two minutes.
Orange color with a glacial acetic acid solution of benzidine.
Reduced Fehling's solution, giving cuprous oxide precipitate.
Gave positive test with Tollen's reagent.

When treated with a saturated solution of sodium bisulphite a portion of the oil reacted to form crystals of a bisulphite addition product. The unaltered portion, which was separated from the crystals, had a pinenelike odor and appeared to consist of a mixture of terpenes.

The crystalline bisulphite addition product was purified by washing with alcohol and ether. It was then treated with sodium carbonate solution and distilled. The oil, which passed over into the distillate, was separated from water and dried with sodium sulphate. This oil, which had an odor resembling citronellal, was tested for this substance by shaking it with an acidified solution of mercuric sulphate. A bright yellow color which remained for some time served as a positive test for citronellal.[8]

The citronellal content of the original colobot-peel oil was determined quantitatively according to the method recommended by Baker and Smith.[9] The oil was poured into a flask, which had a narrow graduated neck, and treated with a 30 per cent solution of commercial sodium bisulphite. The citronellal combined with the sodium bisulphite. The addition of water forced the uncombined oil into the neck of the flask, where it was measured. As a result of this test the colobot-peel oil was found to contain 26 per cent citronellal.

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[8] Leach, A. E., and A. W. Winton, Food Inspection and Analysis (1920) 939.

SUMMARY

The citrus fruit colobot [*Citrus hystrix* DC. var. *torosa* (Blanco) Wester] grows wild and is also cultivated to some extent in Batangas Province, Luzon, in the Philippines. Locally the crushed fruits are mixed with gogo (pounded stems of *Entada phaseoloides*) and used as a shampoo for cleaning the hair. The crushed rind of the fruit is also added to coconut oil to give it fragrance when applied to the hair.

Recently, we investigated the essential oil obtained from the peel of the colobot fruit. The yield of essential oil obtained by steam-distilling the peel was found to be 2.15 per cent, which is rather high for a natural perfumery product. This oil has a very fragrant and refreshing (limelike) fruity odor and should serve as a useful constituent for making perfume bouquets.

The physical and chemical constants of the essential oil obtained from colobot peel were determined and also the temperatures at which the oil distils.

An investigation to determine the characteristics of this oil showed that it gave very decided tests for double-bond compounds and also for aldehydes.

When treated with sodium bisulphite solution a portion of the oil reacted to form a crystalline bisulphite addition product. The unaltered portion, which was separated from the crystals, had a pinenelike odor and appeared to consist of a mixture of terpenes. By decomposing the crystalline addition product there was obtained an oil which gave a positive test for citronellal.

The citronellal content of the original colobot-peel oil was found to be 26 per cent.

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[9] The Eucalypts and their Essential Oils, Sydney Technological Museum Education Series 24 (1920) 389.

ILLUSTRATION

PLATE 1. View of whole colobot fruit and of the cross and longitudinal sections.

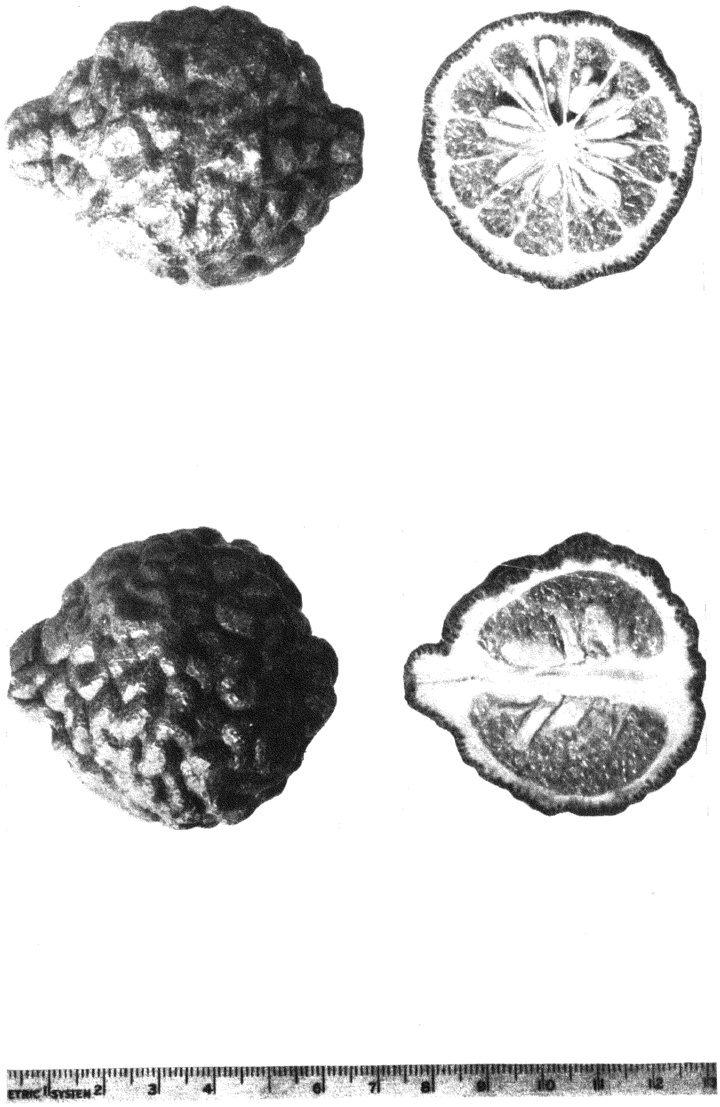


PLATE 1.

UNIV OF MICH

THE IDENTITY OF ANOTA VIOLACEA AND RHYNCHOSTYLIS RETUSA

By EDUARDO QUISUMBING

Botanist, National Museum Division, Bureau of Science, Manila

THREE PLATES

The object of this paper is to throw some light on the nomenclatural confusion of two very interesting species of orchids which are abundant in the Philippines. True *Anota violacea* has not been very well recognized in the Philippines, and orchidologists in foreign countries have confused this species with others under different genera.

Anota violacea had been much confused with *Rhynchostylis retusa,* and often erroneously identified as *Aërides, Saccolabium, Sarcanthus,* or *Vanda.* It is often taken to be in the Philippines either as *Aërides quinquevulnerum* Lindl. or *Aërides Jarckianum* Schltr. Fortunately, however, *Aërides Jarckianum* shows marked differences in both vegetative and floral characters. Both *Anota violacea* and *Rhynchostylis retusa* are very common species in Manila, and during their season of flowering these two species are sold by peddlers in Manila; *Anota violacea* appearing in the streets and in the market during the months of December to March and *Rhynchostylis retusa* during the months of June to September. Even in culture under similar conditions the flowering period of the two species is different. Both, however, are much alike in habit and in vegetative features, particularly the leaves. When not in flower, it is very difficult to recognize them by the leaves alone unless one has had considerable experience. Deviating from the conventional method of presenting a synoptic key to these two species, I have tabulated the differences as one sees them in their living state. Also I have appended here a complete bibliography and description of the two species in question based on living specimens.

In addition to these discrepancies the two species differ in the size of the flowers, the form of the labellum, particularly the tip, the placement of the floral segments, etc., as may be seen in the accompanying colored plate.

	Anota violacea.	*Rhynchostylis retusa.*
Leaves	Thicker, wider, the yellowish lines very conspicuous.	Thinner, narrower, the yellowish lines not so conspicuous.
Racemes	Rather loosely flowered	Densely flowered.
Color of flowers	White, with conspicuous purple maculations on sepals and petals, the labellum phlox purple.	White, or with one or very few purple dots on sepals and petals, the labellum light mallow purple.
Odor of flowers	Very fragrant	Odorless.
Flowering period	December to March	June to September.
Duration of flowers	Lasting over two weeks	Lasting only about a week.
Labellum	Sessile, directly attached to the base of the footless column; disc with fleshy lines near the base and with a prominent fleshy callus beneath near the apex.	Attached to a foot, or prolongation of the base of the column; disc without fleshy thickenings (lines or calli).
Spur	Subcompressed, subacute	Compressed, broadly obtuse or truncate.
Capsules	Large, 3.8 to 4.3 cm long, 1.5 to 1.7 cm in diameter.	Small, 2 to 2.5 cm long, 0.8 to 1.1 cm in diameter.

Genus RHYNCHOSTYLIS Blume

RHYNCHOSTYLIS RETUSA (Linn.) Blume. Plate 1, figs. 1 to 4; Plate 2, fig. 1; Plate 3, fig. 1.

Rhynchostylis retusa (Linn.) Blume, Bijdr. (1825) 286, *fig. 49;* Reichb. f. in Bonpl. 5 (1857) 40, in Walp. Ann. 6 (1864) 887 (and vars.); Rolfe in Journ. Bot. 23 (1885) 216; Vidal, Phan. Cuming. Philip. (1885) 150, Rev. Pl. Vasc. Filip. (1886) 271; Hook. f., Fl. Brit. Ind. 6 (1890) 32; Veitch, Man. Orch. Pl. pt. 7 (1891) 53; *t.* (and vars.); Stein, Orchideenb. (1892) 536, *fig. 164* (and vars. and forms); Grant, Orch. Burma (1895) 290 (and vars.); Ridl. in Journ. Linn. Soc. 31 (1896) 294, 32 (1896) 356; King and Pantl in Ann. Roy. Bot. Gard. Calc. 8 (Orch. Sik.-Himal.) (1898) 213, *t. 284;* Trim., Handb. Fl. Ceylon 4 (1898) 187; Rolfe in Orch. Rev. 9 (1901) 281, *fig. 42* (var. *guttata*); Cogn. in Dict. Icon. Orch. (1902) Rhynchost. *t. 1;* J. J. Sm., Fl. Buitenz. 6 (Orch. Jav.) (1905) 629, Fig.-Atlas (1914) *fig. 471;* Duthie in Ann. Roy. Bot. Gard. Calc. 9 (Orch. Northwest Himal.) (1906) 143; Ridl., Mat. Fl. Mal. Penin. 1 (1907) 158; Ames, Orch. 2 (1908) 255, 5 (1915) 219; Merr., Sp. Blancoanae (1918) 117; Ames in Merr. in Journ. Roy. Asiat. Soc. Straits Branch, Special No. (1921) 197, in Merr. Enum. Philip. Fl. Pl. 1 (1925) 423.

Epipendrum retusum Linn., Sp. Pl. (1753) 953, ed. 2 (1763) 1351; Poir. in Lam. Encycl. Suppl. 1 (1810) 384.

Aërides retusum Sw. in Schrad. Journ. Bot. 2 (1799) 233; Willd., Sp. Pl. 4 (1805) 130; Pers., Syn. Pl. 2 (1807) 522; Spreng., Syst. Veg. 3 (1826) 719; Grah., Cat. Pl. Bomb. (1839) 204.

Limodorum retusum Sw. in Nov. Act. Ups. 6 (1799) 80.

Aërides praemorsum Willd., Sp. Pl. 4 (1805) 130; Spreng., Syst. Veg. 3 (1826) 719; Grah., Cat. Pl. Bomb. (1839) 264.

Epidendrum indicum Poir. in Lam. Encycl. Suppl. 1 (1810) 384.

Aërides undulatum Sm. in Rees Cyclop. 39 (1819) No. 13.

Aërides spicatum D. Don, Prodr. Fl. Nepal. (1825) 31.

Epidendrum hippium Buch.-Ham. ex D. Don, Prodr. Fl. Nepal. (1825) 32, in syn.

Rhynchostylis praemorsa Blume, Bijdr. (1825) 286; Hassk. in Hoev. and De Vriese, Tijdschr. Nat. Gesch. 9 (1842) 143; Hassk., Pl. Jav. Rar. (1848) 128.

Sarcanthus guttatus Lindl. in Bot. Reg. 17 (1831) *t. 1443.*

Aërides guttatum Roxb. Fl. Ind. ed. 2, 3 (1832) 471; Regel in Gartenfl. 12 (1863) 339, *t. 415, figs. 8–12;* Morr. in Belg. Hort. 26 (1876) 291.

Saccolabium guttatum Lindl. in Wall. Cat. (1832) No. 7308, nomen, Gen. & Sp. Orch. (1833) 220; Paxt., Mag. Bot. 2 (1835) 141, 6 (1839) 214, 11 (1844) 211; Lindl., Sert. Orch. (1841) sub. *t. 47;* Hook. in Bot. Mag. 70 (1844) *t. 4108;* Griff., Notul. 1 (1847) 22, Icon. Pl. Asiat. 1 (1847) *tt. 8, 9;* Wight, Icon. 5^1 (1852) 19, *t. 1745–6;* Harting, Parad. Vindob. 2 (1848–60) *t. 13;* De Vriese, Ill. Orch. Ind. Neerl. (1854) *t. 14;* Lindl. in Journ. Linn. Soc. 3 (1859) 32; Miq., Fl. Ind. Bat. 3 (1859) 693; Dalz. and Gibs., Bomb. Fl. (1861) 263; Thw., Enum. Pl. Zeyl. (1864) 303; Drury, Handb. Ind. Fl. 3 (1869) 405; Puydt., Orch. (1880) 227, *text cut;* Naves, Novis. App. (1882) 241; Godefr.-Lebeuf in l'Orchidoph. 8 (1888) 273, *t.* (var. *giganteum*), 11 (1891) 11; Meylhand in Journ. des Orch. 2 (1892) 255, in Sem. Hort. 3 (1899) 489; Will., Orch. Grow. Man. ed. 7 (1894) 701 and var.

Saccolabium praemorsum Lindl., Gen. & Sp. Orch. (1833) 221; Paxt., Mag. Bot. 4 (1837) 94; Hassk. in Tijdschr. Nat. Gesch. 9 (1842) 143, Pl. Jav. Rar. (1848) 128; Edit. in Fl. des Serres 7 (1851–52) 92, *text cut;* Miq., Fl. Ind. Bat. 3 (1859) 693; Drury, Handb. Ind. Fl. 3 (1869) 405; Meylhand in Journ. des Orch. 2 (1891) 255, in Sem. Hort. 3 (1899) 489, non Hook. f.

Saccolabium spicatum Lindl., Gen. & Sp. Orch. (1833) 221.

Orchis lanigera Blanco, Fl. Filip. (1837) 641, ed. 2 (1845) 446, ed. 3, 3 (1879) 37.

Saccolabium blumei Lindl. in Bot. Reg. 27 (1841) Misc. 55; Lindl., Sert. Orch. (1841) *t. 47;* Miq., Fl. Ind. Bat. 3 (1859) 693; Puydt, Orch. (1880) 313, *t. 27;* Naves, Novis. App. (1882) 241; Edit. in Gard. Chron. II 23 (1885) 572, *fig. 105;* Warner and Will., Orch. Alb. 4 (1885) *t. 169;* Teran in Ill. Hort. 32 (1885) 125, *t. 566;* Meylhand in Journ. des Orch. 2 (1891) 254; in Sem. Hort. 3 (1899) 489, 516; Will., Orch. Grow. Man. ed. 7 (1894) 699, *t.;* E. L. in Sem. Hort. 2 (1898) 376, *fig. 375.*

Saccolabium macrostachyum Lindl., Sert. Orch. (1841) sub. *t. 47.*

Saccolabium retusum Voigt, Hort. Sub. Calc. (1845) 630; Van Houtte in Fl. des Serres 14 (1861) *t. 1463–4;* Will., Orch. Grow. Man. ed. 7 (1894) 703.

Saccolabium rheedii Wight, Icon. 5^1 (1852) 19.

Saccolabium blumei Lindl. var. *major* Will., Orch. Grow. Man. (1852) 89, ed. 7 (1894) 699; J. Linden, Pescat. 1 (1860) *t. 21;* Lem. in Ill. Hort. 15 (1868) *t. 545;* Meylhand in Journ. des Orch. 2 (1891) 254.

Rhynchostylis guttata REICHB. F. in Bonpl. 2 (1854) 93; ROLFE in Orch. Rev. 22 (1914) 281, *fig. 33.*

Saccolabium gurwalicum LINDL. in Journ. Linn. Soc. 3 (1859) 32; REICHB. F. in Gard. Chron. II 12 (1879) 102.

Rhynchostylis gurwalica REICHB. F. in Walp. Ann. 6 (1864) 888.

Rhynchostylis retusa (Linn.) Blume var. *macrostachya* REICHB. F. in Walp. Ann. 6 (1864) 888.

Saccolabium furcatum HORT. ex Will. Orch. Grow. Man. ed. 3 (1868) 201, ed. 7 (1894) 700.

Saccolabium holfordianum HORT. ex Warner, Sel. Orch. Pl. II (1874) *t. 18.*

Saccolabium littorale REICHB. F. in Gard. Chron. II 16 (1881) 198; HOOK. F., Fl. Brit. Ind. 6 (1890) 33, cf. Ridl. in Journ. Linn. Soc. 32 (1896) 356.

? *Saccolabium berkeleyi* REICHB. F. in Gard. Chron. II 19 (1883) 814, Edit. in l'Orchidoph. 3 (1883) 693; HOOK. F., Fl. Brit. Ind. 6 (1890) 33; WILL., Orch. Grow. Man. ed. 7 (1894) 699.

Saccolabium heathii HORT. ex Gard. Chron. II 24 (1885) 369.

Saccolabium turneri WILL., Orch. Grow. Man. ed. 6 (1885) 568, ed. 7 (1894) 703.

Saccolabium blumei Lindl. var. *russellianum* WILL. in Warner and Will., Orch. Alb. 5 (1886) *t. 238*; WILL., Orch. Grow. Man. ed. 6 (1885) 564, ed. 7 (1894) 699.

Gastrochilus blumei KTZE., Rev. Gen. Pl. 2 (1891) 661.

Gastrochilus gorwalicus KTZE., Rev. Gen. Pl. 2 (1891) 661.

Gastrochilus retusus KTZE., Rev. Gen. Pl. 2 (1891) 661.

Gastrochilus rheedii KTZE., Rev. Gen. Pl. 2 (1891) 661.

Gastrochilus spicatus KTZE., Rev. Gen. Pl. 2 (1891) 661.

? *Rhynchostylis violacea* (Lindl.) Reichb. f. var. *berkeleyi* STEIN, Orchideenb. (1882) 537.

Gastrochilus praemorsus DUR. and JACKS., Ind. Kew. Suppl. 1 (1903) 178, non Ktze.

Rhynchostylis violacea AMES, Orch. 1 (1905) 105, non Reichb. f.

Rhynchostylis retusa
R: foliis apice bifarium retusis.
Synon: *Aerides retusa.*-Sw.
Crescit: supra arbores in Provinciis Bantam et Buitenzorg.
Floret: Februario etc. Blume, Bijdr. 286.

Epiphytic on tree trunks, particularly on *Bauhinia malabarica, Gliricidia sepium,* and *Lagerstroemia speciosa.* Stems stout, 16 to 32 cm long. Roots stout, greenish gray with few white spots, 8 to 12 mm in diameter. Leaves distichous, spreading or arching, lorate, deeply channeled, firm, thickly coriaceous, 11 to 39 cm long, 1.2 to 3.5 cm wide when flattened, imbricated at the base, obliquely 2-lobed or retuse at the apex, dark green above, paler beneath with conspicuous longitudinal yellowish lines. Racemes cylindrical, long, densely-flowered, pendulous, 1 to 4 in a plant, usually 27 to 33.5 cm long, 4 to 5.5 cm in diameter; the peduncles 7 to 10.5 cm long. Flowers crowded, odorless, numerous, 1.7 to 2.3 cm across; pedicellate ovary grooved, 1.5 to 1.8 cm long, or about 1 cm long at the tips of the racemes; bracts membranaceous, 5 to 6 mm long. Sepals and petals spreading, white, sometimes with very few minute light mallow purple dots. Lateral sepals broadly and obliquely ovate, obtuse, 9 to 10 mm long, 7 to 8 mm wide, 7-nerved. Dorsal sepal smaller than the lateral sepals, broadly elliptic, rounded or broadly obtuse, 8 to 9.5 mm long, 6 to 6.5 mm wide, 7-nerved. Petals smaller and narrower than the sepals, oblong-ovate, rounded, 9 to 10 mm long, 4.5 to 5 mm wide, 5-nerved. Labellum strongly saccate-spurred at the base, attached to a foot, or prolongation of the column about 3 mm long, light mallow purple, white at the tip; spur much compressed, white, cylindric-oblong, broadly obtuse to subtruncate, 6.5 to 8 mm long, lamina reflexed at the apex, oblong-spatulate, rounded and apiculate or slightly retuse at the tip, 11 to 12 mm long, 7 to 8 mm wide at the widest portion near the very tip. Column very short, glass-green, about 3 mm long; anther ovoid, beaked; pollinia 2, subglobose or globose, yellowish. Capsules ellipsoid, 1.6 to 2.5 cm long, 7 to 11 mm in diameter, 6-ribbed, the alternate wings 1 to 2 mm wide.

This widely distributed species, which spreads over a geographical area larger perhaps than that of most Indo-Malaysian species, is restricted in the Philippines to Luzon Island, particularly in Bataan and Rizal Provinces, and is represented in the Bureau of Science herbarium by the following collections: *Cuming 2072, Lyon 13, Whitford 36, Merrill 4190, Merrill, Sp. Blancoanae 1030, Reillo 9, Weber 10, Bur. Sci. 13548 Ramos, 85610 Quisumbing.*

Occurs in India, Ceylon, Burma, Malay Peninsula, Siam, Java, and Borneo.

Genus ANOTA Schlechter

ANOTA VIOLACEA (Lindl.) Schltr. Plate 1, figs. 5 to 8; Plate 2, fig. 2; Plate 3, fig. 2.

Anota violacea (Lindl.) SCHLTR., Orchideen (1914) 588.

Vanda violacea LINDL. in Bot. Reg. 27 (1841) Misc. 12, 33 (1847) *t. 30;* PAXT., Mag. Bot. 9 (1842) 119; VAN HOUTTE in Fl. des Serres 17 (1868–69) 92; AMES in Merr. Enum. Philip. Fl. Pl. 1 (1925) 438.

Rhynchostylis violacea REICHB. F. in Bonpl. 2 (1854) 93, in Walp. Ann. 6 (1864) 888; VAN HOUTTE in Fl. des Serres 17 (1868–69) 91; STEIN, Orchideenb. (1892) 537; AMES, Orch. 5 (1915) 219.

Saccolabium violaceum REICHB. F. in Bonpl. 2 (1854) 93, in syn.; WARNER, Sel. Orch. I (1862–65) *t. 14;* PUYDT, Orch. (1880) 317, *t. 39;* NAVES, Novis. App. (1882) 241; VEITCH, Man. Orch. Pl. pt. 7 (1891) 117; CERON, Cat. Pl. Herb. Manila (1892) 168.

The original description reads as follows:

> "VANDA *violăcĕă;* foliis canaliculatis obliquè abscissis rotundatis, racemis multiflores densis pedunculatis, sepalis obovato-oblongis obtusis planis incurvis petalis multò angustioribus, labello oblongo apiculato plano: venis 5 crassis elevatis, sacco intus pubescente.
>
> A very pretty epiphyte, sent from Manilla to Messrs. Loddiges by Mr. Cuming. The flowers are in short racemes, rather large, with an ivory white ground spotted with light violet; of the latter colour there is one large blotch within the extremity of each sepal and petal, and a few small dots are scattered over their surface; the lip is wholly violet. The flowers have a faint and rather disagreeable smell." Lindl. Bot. Reg. 27 (1841) Misc. 12.

Epiphytic on similar hosts as *Rhynchostylis retusa.* Stems stout, usually short, 10 to 18 cm long, (rarely up to 40 cm long), 0.8 to 1.7 cm in diameter. Leaves distichous, broadly strap-shaped, decurved, deeply channeled, firm, very thickly coriaceous, 14 (rarely 6) to 31 cm long, 2 to 4.2 cm wide when flattened, imbricated at the base, unequally 2-lobed or retuse at the apex, green with very conspicuous yellowish lines. Racemes pendulous, shorter than the leaves, loosely-flowered, 7 to 25 cm long, 4.5 to 6.5 cm in diameter, 3 to 5 on a plant. Flowers fragrant or with a distinct odor, 2.5 to 3 cm across; pedicellate ovary, 1.6 to 2.3 cm long; pedicel white; ovary oural green. Sepals and petals fleshy, white, conspicuously spotted with light amparo purple. Sepals oblong-ovate or elliptic-ovate, obtuse, or subacute, 13.5 to 15 mm long, 8 to 9 mm wide, 7- to 8-nerved. Petals smaller than the sepals, oblanceolate or subspatulate, obtuse, 11.5 to 13 mm long, 5 to 6 mm wide, 5-nerved. Labellum fleshy, attached directly to the very abbreviated column-foot which is without prolongation, subquadrate-pandurate, 12 to 13 mm long, 8.5 to 9 mm wide at the widest portion, phlox purple, undulate, sharply retuse-apiculate or with a small ovate-lanceolate lobule at the apex; disc with 5 approximate fleshy ridges at the base and a nipplelike callus beneath near the apex; spur flattened, conic-ellipsoid, 6 to 7 mm long, 3.5 to 4 mm wide, phlox pink flushed with yellowish citrine. Column very short, stout, subterete, 2.5 to 3 mm long, Biscay green minutely spotted with pansy purple. Anther ovoid, hazel, with white beak, about 2.5 mm long. Capsules large, ellipsoid-obconic, 3.5 to 4.3 cm long, 1.5 to 1.7 cm in diameter, sharply 3-angled in section with the thick keels at the angles, 3.5 to 5 mm wide, and with a broad flat band in the center between the sharp corners.

An endemic species known to science only by collections from Nueva Ecija and Rizal Provinces, Luzon Island, and represented by the following numbers: *Lyon 50, Native collector s. n., Bur. Sci. 3090 Curran, 21334 Ramos.*

A species with vegetative characters similar to those of *Rhynchostylis retusa* (L.) Blume but differing radically in the structure of the flowers and in the other characters indicated above.

ILLUSTRATIONS

PLATE 1

FIG. 1. *Rhynchostylis retusa* (L.) Blume; front view of a flower, × 1.
2. *Rhynchostylis retusa* (L.) Blume; side view of a flower, × 1.
3. *Rhynchostylis retusa* (L.) Blume; labellum viewed from above, × 2.
4. *Rhynchostylis retusa* (L.) Blume; side view of pedicellate ovary, column, and labellum, × 2.
5. *Anota violacea* (Lindl.) Schltr.; front view of a flower, × 1.
6. *Anota violacea* (Lindl.) Schltr.; side view of a flower, × 1.
7. *Anota violacea* (Lindl.) Schltr.; labellum viewed from above, × 2.
8. *Anota violacea* (Lindl.) Schltr.; side view of pedicellate ovary, column, and labellum, × 2.

PLATE 2

FIG. 1. *Rhynchostylis retusa* (L.) Blume; habit, much reduced.
2. *Anota violacea* (Lindl.) Schltr.; habit, much reduced.

PLATE 3

FIG. 1. *Rhynchostylis retusa* (L.) Blume; portion of the raceme showing slightly enlarged flowers.
2. *Anota violacea* (Lindl.) Schltr.; racemes of flowers, slightly reduced.

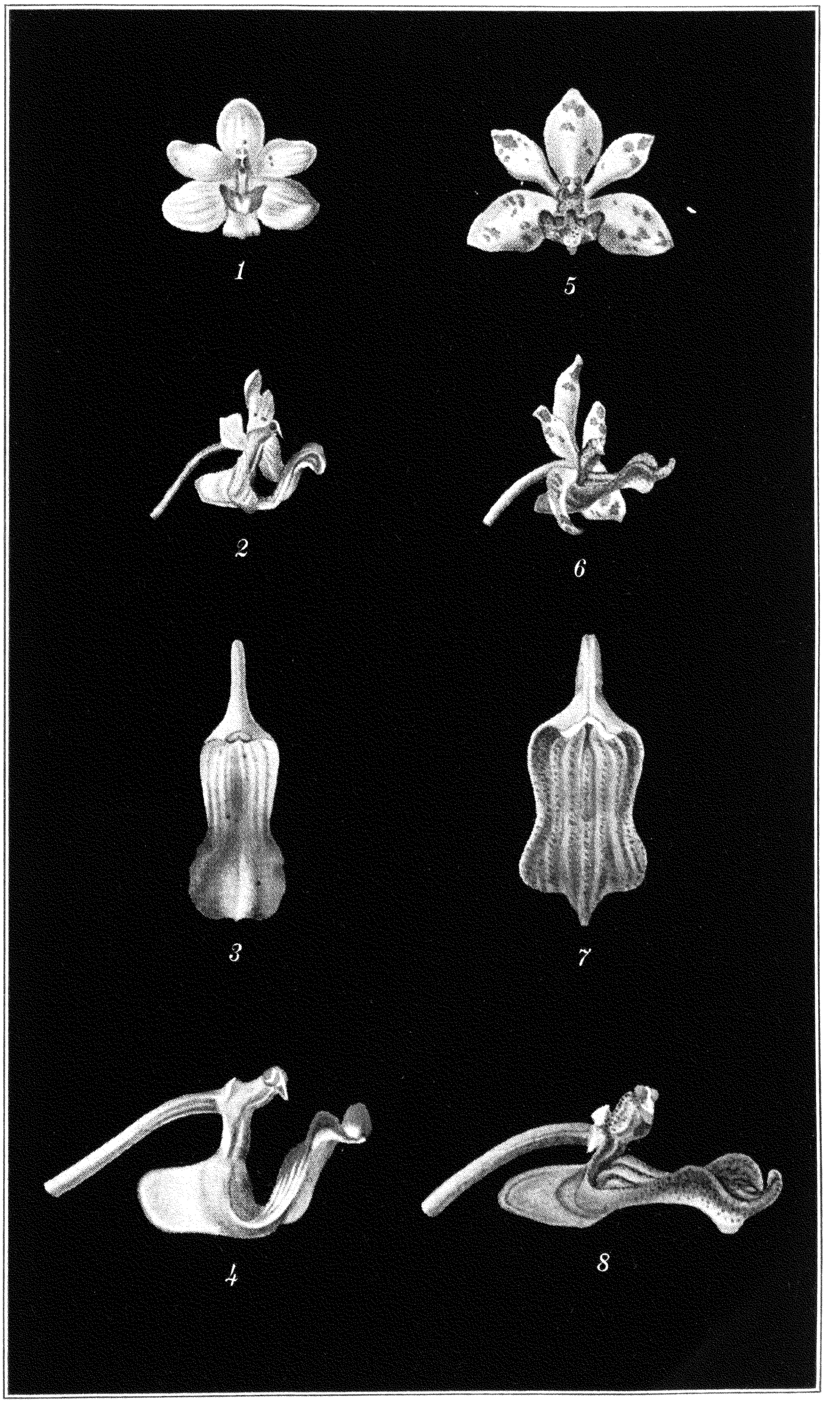
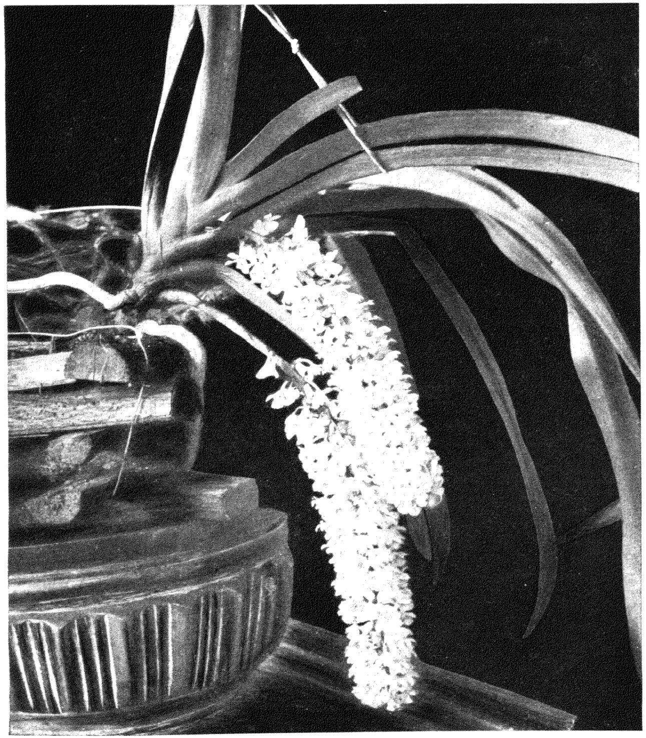


PLATE 1.

UNIV. OF MICH.



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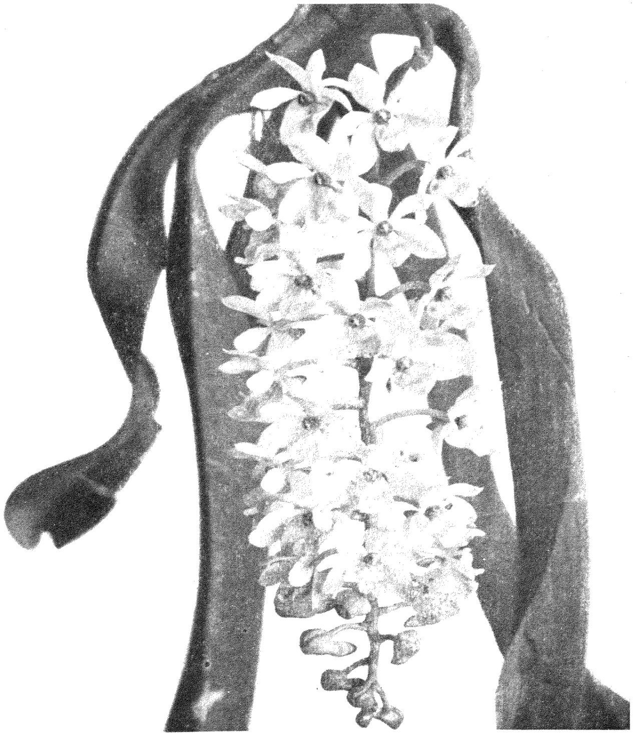

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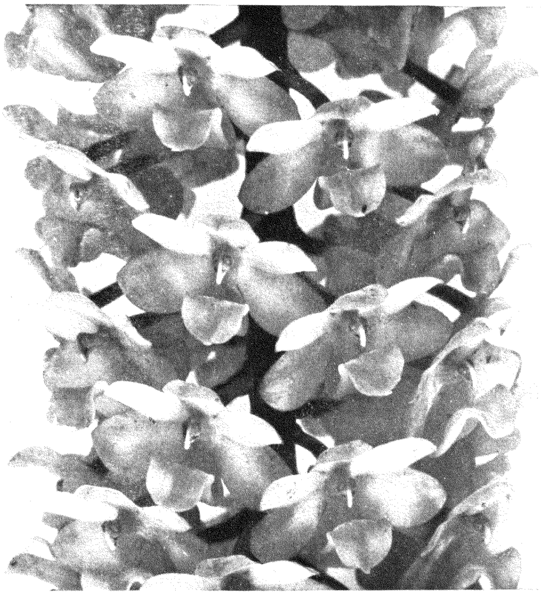
PLATE 2.



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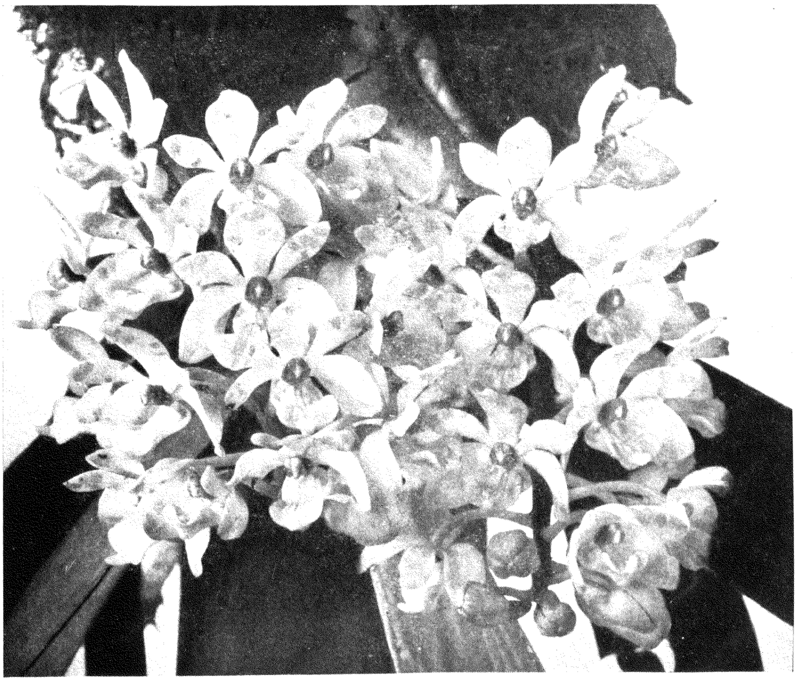

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PLATE 3.

STABILITY OF A NEW CHLORINE PRODUCT

By R. H. Aguilar and Lourdes Ocampo

Of the Bureau of Science, Manila

ONE TEXT FIGURE

Chlorine is, no doubt, one of the most useful chemical products known to science. In the industries, especially in the textile industry, it is used as a bleaching agent; in water supplies, in hospitals, and in medical clinics, as well as in homes, it is used as a disinfectant. Great quantities of chlorine gas were used during the World War. For these reasons the manufacture of chlorine on a commercial basis has become one of the most important problems of industrial chemistry.

Since the discovery of this element by Scheele in 1774, various methods have been developed to prepare it in a form which would make it safe and easy to handle during transportation and distribution. The first attempt in this direction was made by Tennant[1] in Great Britain in 1798. The method consisted in saturating lime with gaseous chlorine:

$$2\ Ca(OH)_2 + 2\ Cl_2 \leftrightarrows 2\ H_2O + Ca(OCl)_2 + CaCl_2.$$

The highest quantity of available chlorine obtainable by this method, however, is 36 per cent, and the product is commercially known as "bleaching powder."

Bleaching powder is made on a large scale in electrolytic alkali works, in order to utilize the large quantities of chlorine that result as a by-product. It is perhaps for this reason that bleaching powder is the cheapest chlorine-carrier produced at present. It is, however, rather unstable in its composition, and under normal conditions prevailing in the Philippines, it deteriorates on storage at a fairly rapid and irregular rate.[2]

In order to eliminate, as far as possible, these objectionable qualities of calcium hypochlorite in bleaching powder, and to manufacture a more stable and a more highly concentrated product, various methods have been devised and developed. Of these methods, the one followed by the Elektron Works at Griesheim,[3] which dates from 1907, may be mentioned. This method consists in saturating milk of lime almost completely with chlorine, and continually stirring it. After filtration the liquid is slowly evaporated in vacuo, thus obtaining solid chloride of lime, purer, more stable, and almost entirely soluble in water.

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[1] Molinari, E., General and Industrial Chemistry. P. Blakiston's Son & Co., Philadelphia (1920) 622.

[2] Aguilar, R. H., Philip. Journ. Sci. 47 (1932) 235.

Very recently a similar chlorine product, commercially known as HTH, appeared on the Philippine market. This product is manufactured by the Mathieson Alkali Works by their own process, and its properties are described by Gage[4] as (*a*) an unusually stable hypochlorite compound; (*b*) of practically uniform composition; (*c*) possessing a high content of available chlorine; (*d*) readily soluble in water; and (*e*) not caking or deliquescing.

COMPOSITION OF THE SAMPLE

The sample tested was furnished by a local drug store, and upon examination gave the following results:

	Per cent.
Sample, 5 g in 200 cc of distilled water.	
Insoluble in water	2.0
Soluble in water	98.0
Total	100.0
Available chlorine	61.0

After a lapse of two years, the bottled sample in the laboratory was again examined, and the following results were obtained.

	Per cent.
Insoluble in water	3.5
Soluble in water	96.5
Total	100.0
Available chlorine	35.0

The principal constituents of the soluble portion besides calcium hypochlorite are KCl, NaCl, and $CaCl_2$. The insoluble portion is mainly $CaCO_3$. SiO_2 and R_2O_3 are both present in the soluble and insoluble portions.

The increase of insoluble matter after two years storage may be attributed to CO_2 in the air, which gained access into the container every time it was opened for the collection of a sample for test. The CO_2 in contact with lime forms the insoluble calcium carbonate.

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[3] Molinari, op. cit. 624.

[4] Chem. and Metal. Eng. 36 (1929) 295.

GENERAL PROCEDURE

The sample of HTH, which was received in original three-liter tin container, was opened, thoroughly mixed, and analyzed. Then a portion of it was placed into two glass bottles, the remaining portion was distributed in several 7 c.c. amber-colored vials, all of which were tightly stoppered. One of the bottles and several vials were stored in the refrigerator, wherein the temperature was maintained at approximately 10°C.; the other bottle and the rest of the vials were stored in the laboratory at an average room temperature of 29° C. The monthly determinations of available chlorine were made according to standard methods. The contents of the bottle were thoroughly mixed by shaking before the sample for analysis was collected. In the case of samples stored in vials, two vials were taken for every test. In some instances marked discrepancies were noticed in the results of tests for available chlorine. When this happened, a third, or even a fourth vial, was tested to check the first determinations.

RESULTS OF TESTS

The results of tests are shown in fig. 1. The curves embrace an observation period of two years. It appears evident from the direction of the curves, that the temperature bears a marked influence on the stability of the bleaching compound. The size of the container and the material of which it is made[5] affect, to a certain extent, its keeping qualities.

There is no noticeable difference between the rates of deterioration of the samples stored in vials and the sample stored in a large bottle at the temperature prevailing in the refrigerator. At the average laboratory temperature, however, the difference is very apparent.

In the course of these observations, it has been noted that the samples in some vials deteriorated more rapidly than in others, and in many instances, redeterminations for available chlorine had to be made to obtain concordant and consistent results. This behavior, which is graphically shown in fig. 1, indicates that the bleaching compound stored in small containers, like

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[5] Philip. Journ. Sci. 47 (1932) 236.

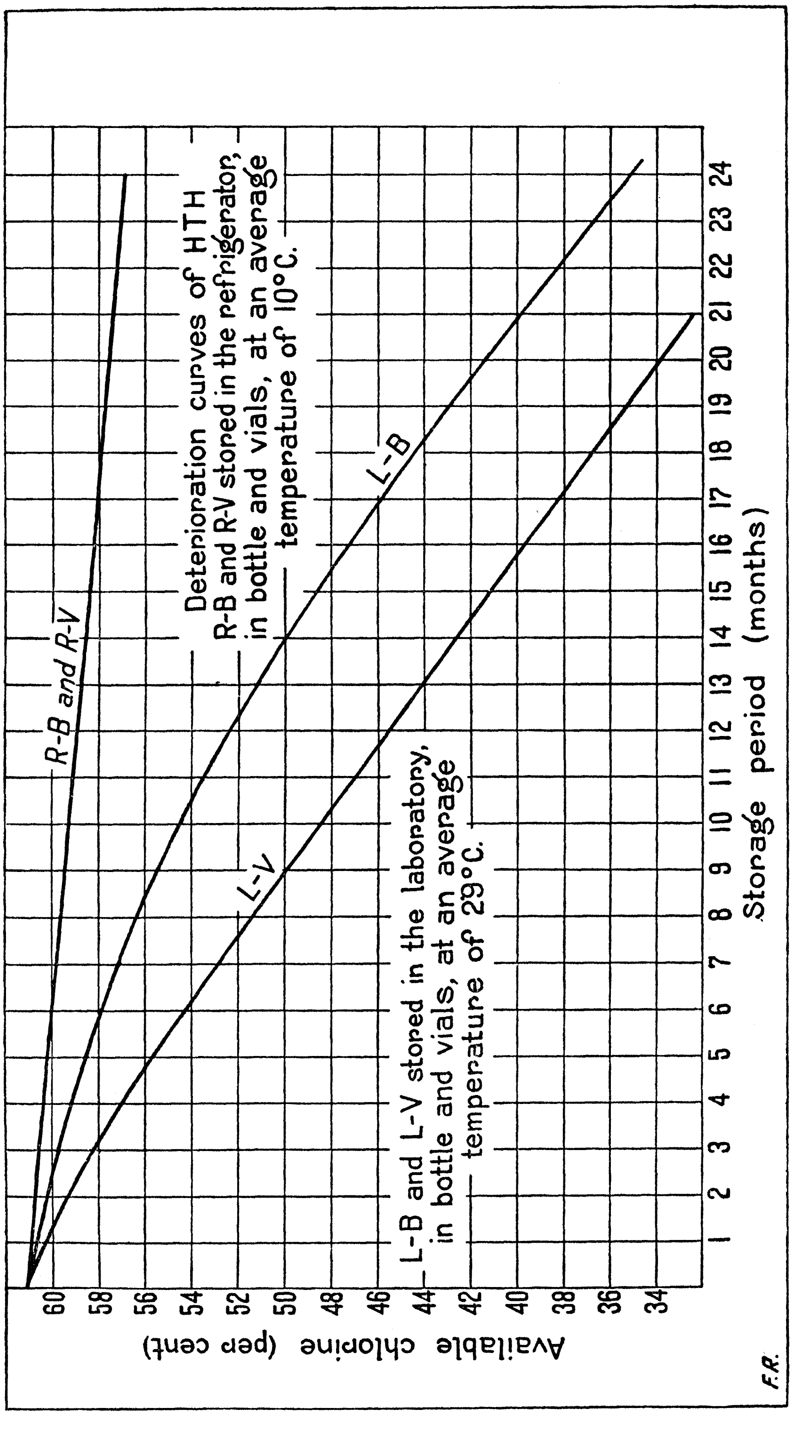

FIG. 1. Deterioration curves of HTH.

these vials, is subject to a relatively more rapid rate of deterioration than the same compound stored in large containers.

FORM AND DIRECTION OF THE CURVES

The deterioration curves plotted on a reduced scale are practically straight lines; but the same curves plotted on an enlarged scale, as shown in fig. 1, are slightly curved downward. The curved direction is especially more noticeable in curve L–B., representing the deterioration rate of the sample kept in a large bottle.

The relatively more rapid deterioration of the samples kept in small containers such as the glass vials used in these tests is shown in curve L–V. At the end of twenty months the samples stored in vials had lost 41 per cent available chlorine, while the same sample stored in a large bottle, lost 32 per cent for the same length of time.

Comparing these curves with those obtained by Gage in 1929 [6] the following relative deterioration values, at different temperatures and after a storage period of about eight months five days, may be obtained.

Loss of available chlorine.

Temperature °C.	Loss. Per cent.
10	2.46
22.5 (Gage's)	4.76
29	7.80
45 (Gage's)	32.69

Although these results show no strict proportional relation between the increase of temperature and the percentage losses of available chlorine, they are yet significant in that they furnish an indication of the uniform quality of the manufactured product. The percentage losses of available chlorine of two different samples appear remarkably consistent with the increase of temperature.

CONCLUSION

HTH is a high-test chlorine-carrier, soluble in water, and exceedingly more stable than bleaching powder of good quality under the normal storage conditions prevailing in the Philippines.

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[6] Chem. and Metal. Eng. 36 (1929) 295.

ILLUSTRATION

TEXT FIGURE

FIG. 1. Deterioration curves of HTH.

RECTIFICATIONS

Par E. FLEUTIAUX

Nogent-sur-Marne, France

FORNAX CORRECTUS nov. nom. pour:

Fornax haddeni FLEUTIAUX, Philip. Journ. Sci. 49 (December, 1932) 565 (non *Fornax* (*Ceratus*) *haddeni* FLEUTIAUX, Proc. Haw. Ent. Soc. (November, 1932) 45.

ELATER CONSPURCATUS Candèze, 1889.

Megapenthes cinctus FLEUTIAUX, Philip. Journ. Sci. 49 (1932) 567.

ADDITIONS TO THE APHID FAUNA OF FORMOSA (HEMIPTERA), II[1]

By RYOICHI TAKAHASHI

Of the Department of Agriculture, Government Research Institute, Formosa

THREE TEXT FIGURES

LACHNUS FICI sp. nov.

Wingless viviparous female.—Brownish black, with the third antennal joint and tibiæ, excepting the distal parts, blackish brown in specimens preserved in alcohol. In specimens treated with caustic potash, antennæ and legs mostly yellowish brown, dorsum dusky on the last abdominal segment, with numerous small pale brown irregular areas densely scattered, and some small dark brown patches, the lateral ones of which are transversely linear. Body oval, covered with many rather fine setæ, which are a little curved and shorter than the first antennal joint. Head distinctly divided, with hairs nearly as long as those on the antennæ and abdomen. Eyes normal. Antennæ slender, with many setæ, which are a little or not curved, equal in length and nearly as long as those on the head; the third joint with one small circular sensorium or none near the tip; the fourth with one or two similar sensoria near the tip; the fifth with the usual sensorium large; the relative length of joints about as follows: III—42, IV—15, V—15, VI—10 + 4. Rostrum reaching beyond the hind coxæ. Abdomen not reticulated on the dorsum, on the dorsum with a small, but distinct, obtuse median tubercle, which is pale dusky in specimens treated with potash, rounded at the tip, much smaller than the cornicle, and with about five small transparent irregular areas on the surface. Cornicles on large cones much wider than long and covered with hairs. Cauda short, broadly rounded, hairy. Anal plate broadly rounded. Legs long, covered with setæ; tibiæ much stouter than the antennæ; hind tarsi not striate, much longer than the fourth antennal joint, the distal joint nearly thrice as long as the basal.

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[1] Part I was published in the Philippine Journal of Science 48 (1932) 69–73.

Length of body, about 4.5 millimeters; antenna, about 1.75; hind tibia, about 3.0; hair on body, about 0.065; diameter of cornicle at apex, about 0.171.

Winged viviparous female.—Brownish black, black on the antennæ, mesothorax, distal halves of tibiæ, and on the tarsi. Fore wings distinctly blackish brown on the basal part, very narrowly dusky on the hind margin, very slightly clouded along the basal parts of the first and second obliques, and narrowly so along the front margin beyond the stigma, the basal blackish brown part not reaching the first oblique; hind wings also distinctly blackish brown on the basal part; stigma and veins blackish brown. (The above color notes are from specimens preserved in alcohol.) In specimens treated with caustic potash, dorsum with some very small dark brown patches, and a pair of large dusky bands on the last segment. Body with rather fine setæ. Head with many curved setæ a little shorter than the first antennal joint. Antennæ a little corrugated on the surface except on the basal two joints, with many setæ, which are slightly curved and as long as those on the head; the third joint with about twenty-six to thirty-eight small or large, circular or subcircular sensoria scattered over the whole length, which are sometimes much fewer (about nine) and absent on the basal part; the fourth with about five to seven similar sensoria not in a row over the whole length; the fifth with one to five small circular sensoria nearly in a row besides a large primary one; the sixth without secondary sensoria; the relative lengths of joints about as follows: III—45, IV—16, V—16, VI—10 + 4. Rostrum reaching beyond the hind coxæ. Abdomen indistinctly minutely reticulated on the dorsum, with hairs nearly as long as those on the head. Wings long; fore wings imbricated on the distal half; stigma much elongated, not reaching the distal end of stigmatic vein; the first oblique nearly straight; the second slightly curved; the third distinct, but slenderer than the second, obsolete on the base, twice branched, the upper branch reaching the tip of wing; stigmatic vein nearly as stout as the third oblique, very slightly curved; hind wings imbricated, with two divergent obliques; hooklets 5. Legs long and slender, covered with setæ, which are slightly curved and stouter than those on the abdomen; hind tarsi longer than the fourth antennal joint, the distal joint nearly thrice as long as the basal.

Length of body, about 5 millimeters; antenna, about 1.6; fore wing, about 6.2; hind tibia, about 3.4; hair on body, about 0.078; diameter of cornicle at apex, about 0.18.

Host.—*Ficus* sp., attacking the branch.

Habitat.—Eboshiyama, near Doba, Rato-Gun.

Many specimens were collected by Dr. T. Shiraki and Mr. M. Chujo, May 20,1933. This species differs from other species of the genus *Lachnus* (*Pterochlorus* Baker) in the basal part of the wings being distinctly blackish brown.

ANOECIA CORNI Fabricius.

Wingless viviparous female.—Dark yellowish brown, blackish on the dorsum. Antennæ and legs brownish black. (Color notes are from specimens preserved in alcohol.) Body oval, covered with rather long fine hairs slightly curved and subequal in length. Head not divided, with many hairs shorter than the first antennal joint. Eyes rather small, of many facets, with normal ocular tubercles. Frontal tubercles absent. Antennæ much shorter than the body, rather stout, six-jointed, covered with long fine hairs, most of which are nearly as long as the first antennal joint; the first joint slightly shorter, but a little stouter, than the second; the third straight, not imbricated, constricted at the base, with one small circular sensorium or none at the tip; the fourth slightly narrowed towards the base, with one or two similar sensoria on the distal half; the fifth similar in shape to the fourth, with the usual circular sensorium large; the sixth striate on the distal part, not pointed apically, very slightly constricted at the base of the distal part; the relative length of joints about as follows: III—83, IV—31, V—35, VI—39 + 10. Rostrum long, stout, reaching a little beyond the hind coxæ, not pointed at the tip, hairy. Cornicles very short, represented nearly as mere rings, but much larger in diameter than the primary sensorium, not on cones. Cauda very short, broadly rounded, hairy. Legs long, covered with long fine hairs; tibiæ stouter than the third antennal joint; hind tarsi long, not striate, longer than the fifth antennal joint, the basal joint short, with some long bristles.

Length of body, about 2.8 millimeters; antenna, about 1.07; hind tibia, about 1.10; longer hair on antenna, about 0.074; width of third antennal joint, about 0.055; diameter of cornicle, about 0.055.

Host.—*Saccharum officinarum*, attacking the subterranean part.

Habitat.—Seiton, Taichu Prefecture.

Some specimens were taken by Mr. M. Yanagihara March 20, 1933. The dorsum becomes dusky when treated with caustic potash. This species spends the summer on the roots of the Gramineæ and the winter on *Cornus* in temperate countries, but in Formosa it has not been found on *Cornus*.

GREENIDEA DECASPERMI sp. nov.

Wingless viviparous female.—Yellowish brown, blackish on the dorsum of abdomen except on the margin. Antennæ black on the distal half. Cornicles black, a little paler on the distal part. Legs yellowish brown. Cauda pale yellowish brown. Hairs on the body brownish black. Body chitinized, with numerous granules on the ventral sides of thorax and abdomen, on the dorsum with many very long stout bristles which are slightly curved and a little branched apically, but those on the posterior part of abdomen scarcely or not branched. Head fused with the pronotum, nearly straight on the front, with about ten dorsal bristles longer than the first antennal joint. Frontal tubercles absent. Eyes normal. Antennæ long, slender, striate, with some very long simple bristles; third joint wanting sensoria; the relative lengths of joints about as follows: III—25, IV—14, V—14, VI—13 + 29. Rostrum slender, reaching a little beyond the hind coxæ. Abdomen circular when seen from above, with a little longer bristles. Cornicles long, stout, slightly curved, narrowed at the base, tapering on the distal portion, broadest near the base, narrowest on the distal part, about six times as long as wide, a little longer than the sixth antennal joint, transversely reticulated distinctly on the basal small area, with many very long stout bristles, and numerous spinules over the distal part. Caudal segment with a process, which is apparently longer than wide, rounded apically, tapering and a little expanded basally. Legs slender, with some bristles; tibiæ striate, hind tibiæ as stout as the third antennal joint; femora striate, with two long, more-eminent bristles on the distal part, which are sometimes a little branched at the tip; hind tarsi much shorter than the bristles on the abdomen.

Length of body, about 1.75 millimeters; antenna, about 1.8; cornicle, about 0.77; caudal process, about 0.041; hind tibia, about 0.75; hair on abdomen, about 0.138; hair on cornicle, about 0.208.

Winged viviparous female.—Antennæ black. Cornicles black, a little paler on the distal part. Wing veins blackish brown, stigma dusky. Bristles on the head and thorax much longer than those on the abdomen and a few of them sometimes a little branched. The third antennal joint a little curved, with about seventeen to twenty, circular or oval, small and rather large sensoria irregularly arranged nearly in a row along the whole length except on the distal small part; the relative lengths of joints about as follows: III—40, IV—23, V—23, VI—17 + ?. Cornicles very long, slender, cylindrical, slightly curved, slightly narrowed on the distal part, striate or indistinctly reticulated transversely except on the distal part, nearly as stout as the femur, with many very long bristles, and numerous spinules on the distal part. Femora striate; tibiæ striate, slender, hind tibiæ somewhat curved, slenderer than the third antennal joint. Wing veins normal.

Length of body, about 2 millimeters; cornicle, about 1.65; fore wing, about 2.7; hind tibia, about 1.5; longer bristle on head, about 0.138; longer dorsal bristle on abdomen, about 0.06; longer bristle on cornicle, about 0.28.

Host.—Decaspermum fruticosum.

Habitat.—Taihoku, Suisha.

A few specimens were collected by the author April 24, 1933, at Taihoku, and in June, 1933, at Suisha. This species seems to be allied to *Greenidea mangiferæ* Takahashi, but may be distinguished from it by the longer caudal process and the characters of cornicles of the wingless form, and by the larger sensoria on the third antennal joint of the winged form.

ACYRTHOSIPHON KUWANAI sp. nov.

Wingless viviparous female.—Shining brownish yellow. In specimens treated with caustic potash, dorsum somewhat pale brownish, antennæ yellowish brown, blackish on the apices of the third, fourth, and fifth joints and on the sixth, black on the first except on the base paler, cornicles dusky yellowish brown, with the distal parts darker, legs yellowish brown, black on the distal halves of femora, the distal parts of tibiæ and on the tarsi, cauda yellowish brown. Body oval. Head with numerous spinules over the dorsum except on the median part and near the eyes, eight rather long stout stiff dorsal setæ very slightly or scarcely knobbed at the tip, and a pair of curved stout setæ on the front. Frontal tubercles large, distinctly convex and with two stout setæ on the mesal side, slightly diverging or nearly parallel on the mesal sides. Antennæ very long, slender, imbricated; the first joint very large, twice as long as the second, a little convex on the middle of mesal side; the third and the following joints with a few very small stout setæ, some of which are very slightly capitate; the third with one or two small circular sensoria on the basal part; the fourth lacking sensoria; the relative lengths of joints about as follows: III—49, IV—36, V—35, VI—11 + 48. Rostrum stout, rounded apically, reaching the hind coxæ. Thorax with many rows of spinules on the venter and more or less reticulated on the middle of metasternum; pronotum with a few slightly capitate setæ a little shorter than those on the dorsum of head; mesonota and metanota and dorsum of the abdomen with a few minute setæ a little expanded on the middle and pointed apically; abdomen distinctly corrugated behind each cornicle, with a few curved stout setæ slightly capitate on the dorsum of the posterior part, which are a little shorter than the setæ on the head, and with some simple ventral setæ, which are also a little shorter than the setæ on the head. Cornicles very long, rather slender, expanded on the basal part, nearly straight, roughly imbricated, not reticulated, about six times as long as wide, about twice as long as the cauda, much shorter than the third antennal joint, with a flange at the tip. Cauda large, tapering gradually, about twice as long as wide, with two slight constrictions, two pairs of long curved lateral bristles, and a median one. Legs very long; coxæ imbricated, with some rather long stout setæ; femora long, with many short stiff setæ slightly capitate, and about eight to twelve small circular sensoria scattered on the basal part; tibiæ stouter than the

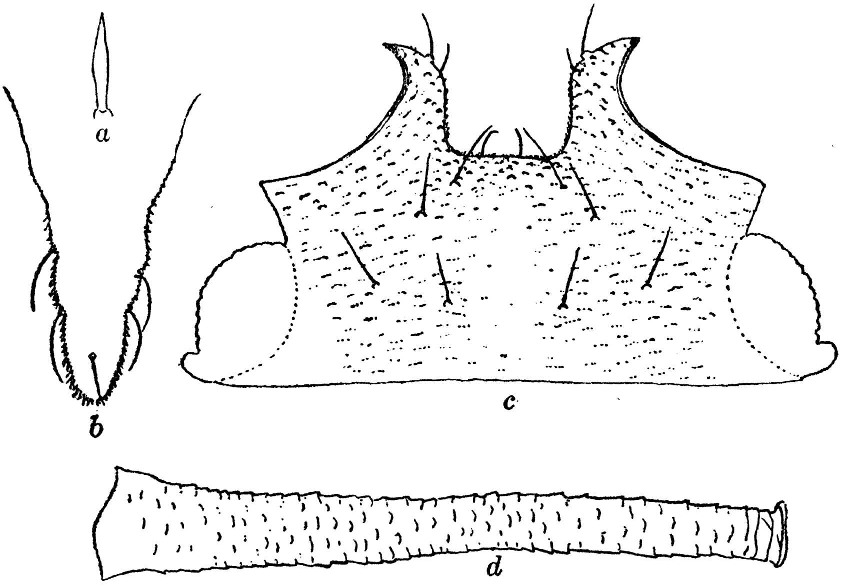

FIG. 1. *Acyrthosiphon kuwanai* sp. nov.; wingless viviparous female; *a*, dorsal seta; *b*, cauda; *c*, head; *d*, cornicle.

third antennal joint, on the basal part as stout as the distal part of cornicle, with many stout setæ, the setæ on the basal part slightly capitate; tarsi somewhat imbricated, much shorter than the basal part of the last antennal joint, the basal joint with two setæ on the distal part.

Length of body, about 1.5 to 1.8 millimeters; antenna, about 3; cornicle, about 0.508; cauda, about 0.245; hind femur, about 1.1; hind tibia, about 1.9; dorsal seta on head, about 0.046.

Host.—*Vitis* sp.

Habitat.—Rarasan (altitude about 6,700 feet), near Urai.

Some specimens were collected by the author July 31, 1933. This species is characterized by the peculiar setæ on the dorsum. Named in the memory of the late Dr. I. Kuwana, who has contributed to the study of the Aphididæ of Japan.

AKKAIA TAIWANA sp. nov.

Wingless viviparous female.—Slightly pale brownish white, somewhat shining. Antennæ, legs, and cauda similar in color, but slightly dusky on the tarsi. Cornicles jet black even in specimens treated with potash. Oval, broadest about the middle of abdomen, with a few minute dorsal setæ slightly capitate. Head with many small granules on the posterior part of dorsum, and six minute dorsal setæ somewhat capitate. Eyes distinctly protruding, with distinct ocular tubercles. Frontal tubercles large, not imbricated, lacking granules, with an eminent mesal tubercle, which is much longer than wide, rounded apically, not curved, reaching the middle of the first antennal joint, and with about four minute setæ expanded towards the tip. Antennæ much shorter than the body, distinctly imbricated on all the joints, five-jointed, with a few minute stout capitate setæ; the 1st joint wider than long, distinctly convex on the mesal side, a little protruding obtusely at the base of lateral side; the second somewhat shorter than the first but longer than the frontal tubercle, longer than wide, the third not imbricated on one side, slightly constricted near the distal end, lacking sensoria; the fourth on the distal part with a rather large circular sensorium which is not smooth on the surface; the relative length of joints about as follows: III—82, IV—25, V—20 + 40. Rostrum stout, reaching a little beyond the middle coxæ. Thorax with many spinules on the venter. Abdomen with numerous eminent dusky spinules in transverse rows behind each cornicle and on the last segment, and some very short simple setæ on the venter; abdominal segments not discernible, but the eighth segment defined, broadly rounded on the hind margin. Cornicles large, very stout, a little curved, a little broadened towards the base, constricted on the apical part, stouter than the cauda, about thrice as long as wide, eminently imbricated, not reticulated, nearly as long as the third antennal joint, about 2.8 times as long as the cauda, directed posteriorly, with a distinct flange at the tip. Cauda large, stout, about 1.6 times as long as wide, somewhat constricted at the base and the middle, a little expanded on the distal part, but a little narrowed on the apex, rounded apically, with two pairs of rather short fine lateral setæ. Anal plate rather large, a little protruding on the distal part, wide, broadly rounded apically, with six rather long setæ. Gonapophyses distinct, three in number. Genital plate extremely large, projecting posteriorly, rounded on

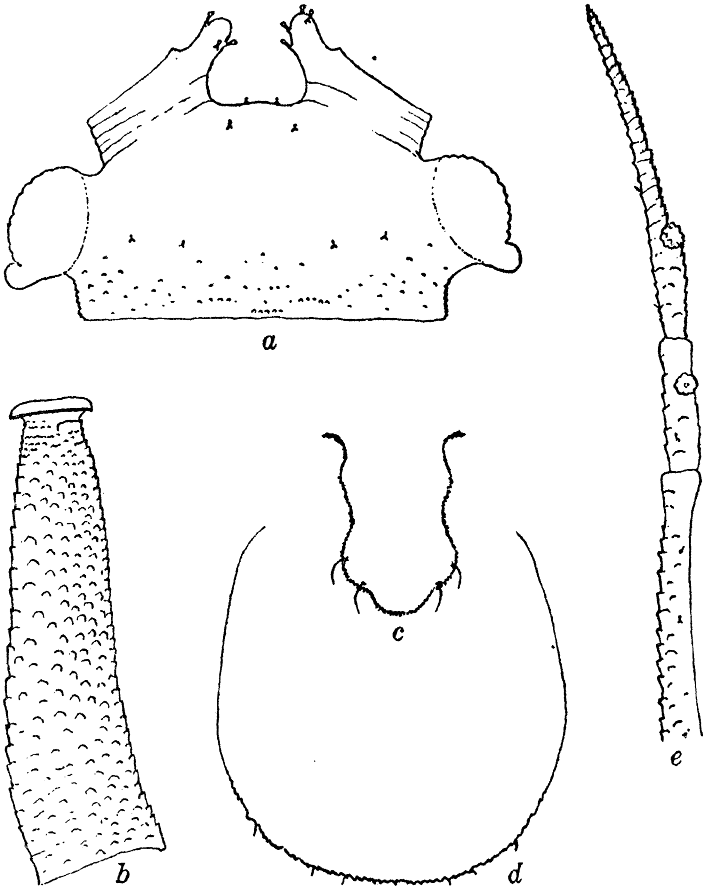

FIG. 2. *Akkaia taiwana* sp. nov.; wingless viviparous female; *a*, head; *b*, cornicle; *c*, cauda; *d*, genital plate; *e*, distal part of antenna.

the side, broadly rounded on the hind margin, as long as wide, imbricated and with many spinules on the hind half, reaching beyond the middle of cauda, with a few small setæ on the hind margin. Legs long, slender, with some short setæ; tibiæ stouter than the third antennal joint; tarsi slightly striate, the basal joint with two setæ near the tip; hind tarsi as long as the basal part of the last antennal joint.

Length of body, about 1.8 millimeters; antenna, about 0.9; cornicle, about 0.4; cauda, about 0.14; anal plate, about 0.08; genital plate, about 0.29; hind femur, about 0.5; hind tibia, about 0.9.

Host.—*Polygonum* sp.

Habitat.—Ikenohata, Rato-Gun.

Many specimens were collected by the author August 1, 1933. This species differs from *Akkaia polygoni* Takahashi in the following characters: (*a*) The second antennal joint less protruding on the mesal side; (*b*) the distal part of the last antennal joint longer; (*c*) the frontal tubercles with a mesal tubercle not curved; (*d*) the abdomen wanting dorsal tubercles; (*e*) the cornicles jet black, shorter, not so much narrowed on the distal part; (*f*) the genital plate broadly rounded posteriorly.

GLYPHINAPHIS BAMBUSAE van der Goot.

Contr. Fauna Indes Neerland. 1, 3 (1917) 232; Tijdsch. Ent. 60 (1918) 113.

Host.—*Bambusa* sp., attacking the lower side of leaf.

Habitat.—Suisha.

Previously known from Java and Singapore. Two apterous females were taken by the author June 12, 1933. The specimens are different from the original description in the body being somewhat reddish brown and smaller, measuring about 1.5 millimeters in length, as well as in the fourth antennal joint being nearly as long as the third. These characters are variable in this group, and I regard the Formosan aphid as identical with this species. The apterous females are provided with numerous small poorly developed pores, irregular in outline, over the dorsum, and the marginal setæ are variable in length.

HAMAMELISTES TUBERCULATUS Takahashi.

Thoracaphis tuberculatus TAKAHASHI, Stylops 2 (1933) 30.

Winged viviparous female.—Head, antennæ, and thorax black. Legs gray. Abdomen pale greenish yellow. Wings fuscous, very slightly clouded along the obliques, with the stigma and veins gray. Body oblong. Head imbricated, with eight very short setæ on the dorsum. Eyes large, with normal ocular tubercles. Front ocellus on a small protuberance on the front, which is narrow. Antennæ short, not striate, but constricted between the sensoria, four- or five-jointed, without eminent setæ; the first joint wider than long, nearly as long as the second; the third slightly longer than the front tibia, stouter than the basal part of it, with nine or ten linear sensoria in a row, which occupy nearly the entire circumference of the joint; the fourth with two to four similar sensoria; the fifth with two or three similar sensoria; the relative lengths of joints about as follows: III—41, IV—14, V—11 in the five-jointed antennæ, III—41, IV—20 in the four-jointed antennæ. Rostrum stout, the last joint slender, tapering, pointed at the tip, longer than the penultimate joint, not reaching the middle coxæ. Thorax without wax pores; mesonotum not divided into lobes, with a pair of very short setæ on the middle part. Abdomen with no setæ distinct. Cornicles small, very short, broadened toward the base, much wider than long. Cauda small, distinctly constricted, knobbed part somewhat wider than long, globular, a little wider than the apex of cornicle, with about six setæ. Anal plate bilobed, each lobe much wider than long, rounded, somewhat wider than the cauda, with about six setæ. Tibiæ a little broadened on the distal part, with many transverse rows of minute spinules, and a few short setæ on the distal part; hind tarsi nearly as long

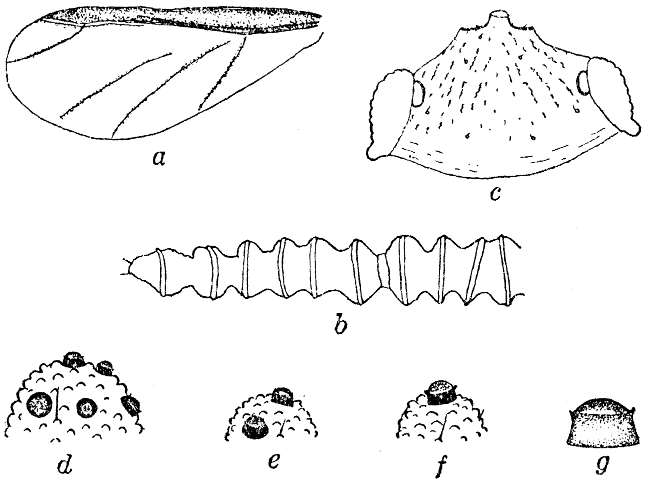

FIG. 3. *Hamamelistes tuberculatus* Takahashi, winged viviparous female; *a*, fore wing; *b*, distal part of antenna; *c*, head; nymph of winged viviparous female, *d*, *e*, *f*, dorsal tubercles; *g*, protuberance on dorsal tubercules.

as the last antennal joint, with two pairs of very long fine hairs somewhat capitate on the distal joint. Wings ample, imbricated, held horizontally in repose; the first oblique on the front wing slightly stouter than the second, slightly curved; the second slightly curved, not united with the first; the third obsolete on the basal part, not branched, very slightly curved; stigmatic vein slightly curved, nearly reaching the tip of wing; stigma normal; hind wings without obliques, hooklets two.

Length of body, about 1.15 millimeters; antenna, about 0.4; hind tibia, about 0.25; fore wing, about 1.5.

Nymph of winged viviparous female.—Pale yellow, with no secretion eminent. Dorsum covered with numerous very short rounded papillæ, and with many large rounded tubercles, which are wider than long, covered with many small papillæ similar to those on other parts of dorsum and with one to six short chitinized protuberances as shown in the figure; anterior dorsal tubercles larger than the posterior and lateral tubercles larger than the mesal, the number of these dorsal tubercles as follows: Head, a large pair; prothorax, a large one on the side and two small pairs on the median area; meso- and metathoracic and basal abdominal segments, four in a transverse row; the second and third abdominal segments, six in a transverse row; other abdominal segments, two to four; protuberances on the dorsal tubercles circular when seen from above, much wider than long, smaller in diameter than the apex of cornicle, rounded apically, pale brown in specimens treated with potash. Antennæ large, stout, three-jointed, without hairs.

Host.—*Quercus gilva,* attacking the lower side of leaf.

Habitat.—Taihoku, Sozan.

The aleyrodiform female was described as a *Thoracaphis* in the previous paper. Many winged forms and a few wingless ones were observed in January, 1933. This species differs from *Thoracaphis* in the following characters: (*a*) Antennæ not striate, but constricted between the sensoria in the winged form; (*b*) the third oblique (media) on the front wing not branched; (*c*) hind wings with no obliques; (*d*) cauda not constricted in the aleyrodiform female; (*e*) tarsi not segmented, without claws in the aleyrodiform female.

Referable to *Hamamelistes* Shimer, although differs from the typical forms of the genus.

(All the type specimens are kept in the collection of the Department of Agriculture, Government Research Institute, Formosa.)

ILLUSTRATIONS

TEXT FIGURES

FIG. 1. *Acyrthosiphon kuwanai* sp. nov.; wingless viviparous female; *a,* dorsal seta; *b,* cauda; *c,* head; *d,* cornicle.

2. *Akkaia taiwana* sp. nov.; wingless viviparous female; *a,* head; *b,* cornicle; *c,* cauda; *d,* genital plate; *e,* distal part of antenna.

3. *Hamamelistes tuberculatus* Takahashi, winged viviparous female; *a,* fore wing; *b,* distal part of antenna; *c,* head; nymph of winged viviparous female, *d, e, f,* dorsal tubercles; *g,* protuberance on dorsal tubercles.

NEW OR LITTLE-KNOWN TIPULIDÆ FROM EASTERN ASIA (DIPTERA), XVI[1]

By CHARLES P. ALEXANDER
Of Amherst, Massachusetts

FOUR PLATES

The crane flies discussed herein are chiefly from eastern Siberia, where they were included in the very large and valuable collections belonging to the Russian Academy of Sciences, Leningrad, having been sent to me for determination through the kindly intervention of Drs. Theodore Pleske and A. von Stackelberg. All types resulting from this series are preserved in the collection of the Russian Academy. A few other specimens were taken in Szechwan, China, by Messrs. George M. Franck and David C. Graham, the types of the latter collector being contained in the United States National Museum, of the former in my own collection. I am greatly obliged to the above-mentioned scientists for their appreciated interest in sending me these specimens.

TIPULINÆ

TIPULA (TIPULA) STACKELBERGI sp. nov. Plate 1, fig. 1; Plate 2, fig. 25.

Belongs to the *tricolor* group, allied to *sulphurea;* general coloration gray, the præscutum with four brown stripes; mediotergite yellow, with a large light gray area on either side of median line; antennal segments beyond the third almost uniformly darkened; wings with a nearly uniform brownish yellow tinge, with no darker areas excepting the yellowish brown stigma; abdominal tergites yellowish, the outer segments, including hypopygium, more brownish black; male hypopygium with the tergal region produced into a triangular point at each outer angle; notch of ninth sternite with two small clavate lobes.

Male.—Length, about 14 millimeters; wing, 15.

Frontal prolongation of head yellowish white above, light brown on sides beneath; nasus distinct; palpi with basal seg-

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[1] Contribution from the entomological laboratory, Massachusetts State College.

ment testaceous, the outer segments passing into dark brown. Antennæ broken at the ninth segment; relatively long, if complete extending about to base of abdomen or slightly beyond; scape and pedicel obscure yellow; first flagellar segment clear light yellow, the succeeding segments very vaguely bicolorous, the basal enlargement brownish black, the remainder of segment dark brown, outermost segments more uniformly brownish black; segments much longer than the verticils. Head light gray, with a capillary blackish median vitta.

Pronotum gray. Mesonotal præscutum light gray, with four brown stripes, the intermediate pair nearly contiguous, separated by a capillary blackish vitta; scutum light gray, the lobes variegated with more brownish gray; scutellum buffy, the color continued laterad along the posterior border of the scutal lobes to wing root; mediotergite yellow with a light gray area on either side of the median line, occupying about the distal three-fourths of the sclerite on either side of the midline; a very delicate impressed median line on distal third of mediotergite. Pleura with the anepisternum, sternopleurite, and meron clear light gray; posterior sclerites of pleura obscure yellow, sparsely pruinose, especially the pleurotergite; dorsopleural region light yellow. Halteres relatively long, the stem pale yellow, the knobs weakly darkened. Legs with the coxæ light gray pruinose, the posterior coxæ much paler, more yellowish gray; trochanters yellow; femora yellow, the tips narrowly blackened, the amount subequal on all legs; tibiæ brown, the tips darker; tarsi black. Wings (Plate 1, fig. 1) with an almost uniform brownish yellow tinge, the costal and prearcular regions brighter yellow; stigma pale yellowish brown; restricted obliterative areas before stigma and across base of cell 1st M_2; veins brown. Venation: Rs long, about two and one-half times m-cu; cell 1st M_2 long, parallel-sided; fork of M_{3+4} lying before level of r-m.

Abdominal tergites chiefly yellow, with scarcely darker more brownish yellow areas on sides; tergites with transverse blackened areas; outer segments, including hypopygium, brownish black. Male hypopygium with the caudal margin of tergite (Plate 2, fig. 25, 9*t*) terminating in two slender darkened lobes that are separated only by a linear slit, the apices of the lobes set with conspicuous blackened spicules; lateral angles of tergite further produced into subacute points. Ninth sternite, 9*s*, notched medially, at extreme base of incision with a pair of dusky clavate lobes that are densely covered with small setæ; these lobes do not jut caudad beyond the general level of the sternite, as is the case in *sulphurea* Doane and *subsulphurea* sp. nov., but lie deep in the notch of the sternite. Inner dististyle, *id*, deeply bifid, the outer part more elongate and tipped with erect spines. Gonapophyses, *g*, appearing as pale spatulate blades with very slender stems.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Tigrovaja, Suchan district, June 16, 1927 (*Stackelberg*), No. 81.

I take great pleasure in naming this very distinct crane fly in honor of the collector, Dr. A. von Stackelberg, custodian of the Diptera in the Russian Academy of Sciences. The nearest regional ally is *Tipula* (*Tipula*) *subsulphurea* sp. nov., which differs in the general coloration of the body, including the clear yellow mediotergite, darkened cubital seam, brightened hypopygium, and details of structure of the male hypopygium.

The reference of the species of the *tricolor* (*lateralis*) group to the typical subgenus may not prove to be justified. The members of the group as known form a compact unit that shows certain definite characters, as the short M_{3+4} and the paddlelike gonapophyses of the male hypopygium. In case these and other lesser characters are deemed sufficient to warrant a separate subgeneric term for the members of the group, the name *Yamatotipula* Matsumura (1916) is available.

TIPULA (TIPULA) SUBSULPHUREA sp. nov. Plate 1, fig. 2; Plate 2, fig. 26.

Belongs to the *tricolor* group, allied to *sulphurea;* antennæ (male) elongate, if bent backward extending to beyond base of abdomen; mesonotal præscutum light gray with four dark brown stripes; posterior sclerites of pleura, together with mediotergite, abruptly pale sulphur yellow; wings pale brownish yellow; a conspicuous brown seam along vein Cu; Rs elongate; cell 1st M_2 narrow; male hypopygium with the two lobes of the tergite slender, set with blackened points, separated by a deep and narrow median incision; ninth sternite slightly produced caudad on either side of midline into a slender fingerlike lobe that is tufted with setæ.

Male.—Length, about 12 millimeters; wing, 11; antenna alone, 4.

Female.—Length, about 16 millimeters; wing, 12.5; abdomen, 12.

Frontal prolongation of head brownish yellow to light yellow; nasus distinct; palpi dark brown. Antennæ (male) elongate, if bent backward extending to beyond the base of abdomen; basal three segments yellow, succeeding two or three segments bicolorous, yellow, with the basal enlargement brownish black; outer segments more uniformly infuscated; flagellar segments elongate, much exceeding the small verticils. Head gray, the vertex with a capillary dark brown median line.

Pronotum dark gray. Mesonotal præscutum light gray, with four dark brown stripes; pseudosutural foveæ punctiform; scutum light gray, the lobes vaguely marked with darker; scutellum and mediotergite abruptly light yellow, the former a very little darker than the latter. Pleura with the anepisternum, sternopleurite, and ventral meral region light gray, the posterior sclerites of pleura, including pleurotergite, abruptly light sulphur yellow; dorsopleural membrane ocherous. Halteres dusky, the extreme base of stem yellow, the knobs dark brown. Legs with the fore and middle coxæ light gray, the posterior coxæ abruptly pale yellow; trochanters yellow; femora yellow, the tips narrowly blackened; tibiæ obscure yellow, infuscated on outer third, the tips blackened; tarsi black. Wings (Plate 1, fig. 2) pale brownish yellow, the prearcular and costal regions clearer yellow; stigma small, pale brown; a conspicuous brown seam occupies the space between the cubital branches, only vaguely crossing Cu_1 into posterior border of cell M; obliterative areas reduced to two small separated spots, one before stigma, the second across base of cell 1st M_2; veins brown, more yellowish in costal flavous areas. Venation: Rs long, nearly two and one-half times m-cu; cell 1st M_2 narrow; m-cu oblique, on M_4 just beyond the fork of the short M_{3+4}, the latter point lying proximad of level of r-m.

Abdominal tergites (male) yellow with a sublateral brown stripe on either side, the lateral margins of segments broadly yellow; hypopygium yellow; sternites yellow, very narrowly darkened laterally, the eighth sternite more uniformly darkened. In female, abdomen elongate; tergites darkened sublaterally, beyond the second segment so extensively so as to reduce the ground color to a narrow median line and pale margins. Male hypopygium (Plate 2, fig. 26) with the sclerites fused into a continuous ring. Ninth tergite, *9t*, with the median region of caudal margin produced into a depressed lobe that is further extended into two lobes that are narrowly but deeply separated, densely set at tips with microscopic blackened points. Outer dististyle, *od*, a very short pale club, provided with long pale setæ. Inner dististyle, *id*, small, ear-shaped, with a darkened spinous lobe on face. Median region of sternite, *9s*, delimited by sutures, each lateral angle produced slightly caudad into a slender lobe that is tipped with a few long setæ. Eighth sternite unarmed.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Spassk, June 4, 1928 (*Obolenskij*), No. 591. Allotype, female, Maiche region, near Shkotovo, June 7, 1927 (*Sokolov*), No. 572.

The closest ally of the present fly appears to be *Tipula* (*Tipula*) *quadrivittata* Staeger, of northern Europe, which has a similar darkened cubital seam but may be readily told by the shorter male antennæ with the flagellum entirely blackened and with the scape and pedicel more or less suffused, together with differences in wing venation and in coloration of the posterior sclerites of the thorax, including both pleura and notum. The fly is likewise allied to *T.* (*T.*) *sulphurea* Doane, of northern North America, which differs in the shorter male antennæ, with more uniformly darkened flagellum, the barely indicated cubital darkening, and slight differences in structure of the male hypopygium.

TIPULA (TIPULA) MORIGERA sp. nov. Plate 1, fig. 3; Plate 2, fig. 27.

Belongs to the *tricolor* group, allied to *lateralis;* general coloration gray, the præscutum with four darker stripes that are narrowly bordered by dark brown; antennæ (male) moderately long, if bent backward extending to shortly beyond base of abdomen, the basal four or five segments pale, the remainder dark brown; pleura whitish; femora yellow, the tips narrowly blackened; wing pattern much as in *lateralis;* M_{3+4} very short to lacking; male hypopygium with the blades of the gonapophyses longer than wide.

Male.—Length, 12 to 13 millimeters; wing, 14 to 15; antenna, about 5.

Female.—Length, about 15 millimeters; wing, 14.

Frontal prolongation of head light yellow; nasus distinct; palpi black. Antennæ (male) relatively long, if bent backward extending to beyond base of abdomen; scape and pedicel light yellow, flagellar segments one to three a little more obscure yellow; suceeding segments passing into dark brown; flagellar segments moderately nodulose, the verticils shorter than the segments. Head light gray, the center of vertex more infuscated, the front pale.

Mesonotal præscutum gray with four darker gray to brown stripes that are narrowly bordered by dark brown, including a capillary median brown vitta; in cases the dark borders of the stripes, with the exception of the median line, are obsolete or nearly so; scutum light gray, the lobes variegated by darker brownish gray areas; scutellum paler than mediotergite, both with a very delicate median brown line. Pleura whitish, the pleurotergite very pale yellow. Halteres yellow, the knobs dark brown. Legs with the coxæ whitish; trochanters yellow; femora yellow, the tips narrowly and conspicuously blackened; tibiæ brownish yellow, the tips blackened; tarsi black. Wings (Plate 1, fig. 3) tinged with brown, patterned about as in *eluta* or *lateralis;* prearcular region yellow; cell M and an obliterative area before cord more whitish; stigma, cell Sc, and seams on anterior cord and m-cu darker brown. Venation: M_{3+4} very short to obsolete, its maximum length about equal to R_2.

Abdominal tergites obscure yellow, with a very broad dark brown sublateral stripe, narrowly interrupted at caudal margins of segments; lateral borders of tergites broadly pale; sternites yellow, the subterminal segments darkened; hypopygium yellow. Male hypopygium with the median tergal plate (Plate 2, fig. 27, 9*t*) with a small U-shaped notch, the lateral lobes truncated and set with dense black setæ, these continued as a line down the ventral face of lobe. Outer dististyle, *od,* long, obtuse at tip, the posterior margin on basal half a little dilated. Inner dististyle, *id,* of characteristic shape, with a semicircular blackened armature at base of beak; group of sensory areas above this blackened collar numbering about 14 or 15; marginal fringe of setæ numerous, the outermost short and strongly curved. Setal brushes of ninth sternite in two separate groups. Gonapophyses *g,* with the blades longer than broad.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Kamen-Rybolov, Lake Chanka, July 8, 1927 (*Stackelberg*), No. 266. Allotype, female, Vladivostok, August 5, 1903 (*Gavronski*), No. 498. Paratopotype, male, July 8, 1927, No. 265. Paratypes, 1 male, Devitza station, Lake Chanka, July 14, 1927 (*Stackelberg*), No. 242; 4 females, Jakovlevka, Spassk district, August 31, 1926 (*Djakonov and Filippjev*), Nos. 115, 116, 125; September 12, 1926, No. 124; 1 male, Spassk, June 4, 1928 (*Obolenskij*).

In the elongate blades of the gonapophyses and nature of the ninth tergite of the male hypopygium, the present fly is closest to *Tipula* (*Tipula*) *couckei* Tonnoir (*gracilenta* Lackschewitz), of Europe, differing conspicuously in the structure of the outer dististyle, which is here more like that of the otherwise distinct *T.* (*T.*) *lateralis* Meigen. The pale basal segments of the flagellum are as in *lateralis* and *montium* Egger, being entirely darkened in the other European members of the group, *cœrulescens* Lackschewitz, *couckei* Tonnoir, and *solstitialis* Westhoff.

TIPULA (TIPULA) PARVINCISA sp. nov. Plate 2, fig. 28.

Belongs to the *tricolor* group, allied to *lateralis;* general coloration of præscutum blue-gray, with four slightly darker gray stripes that are narrowly bordered by bright brown; antennæ (male) moderately long, if bent backward extending to slightly beyond base of abdomen; basal three segments obscure brownish yellow, the succeeding segments dark brown; wings pale yellowish white, cells C and Sc, stigma, and seams on m-cu and distal section of vein Cu_1 darker brown; abdominal tergites with sublateral brown stripes that are narrowly cross-connected before caudal margins; male hypopygium with the median notch of tergite very small, the lateral lobes lacking; blades of gonapophyses broader than long, the stem slender.

Male.—Length, 12 to 14 millimeters; wing, 14.5 to 16.5; antenna, about 5.

Female.—Length, about 18 to 19 millimeters; wing, 18; antenna, about 2.5.

Frontal prolongation of head above light gray pruinose, darker on sides beneath; palpi brownish black. Antennæ of male moderately long, if bent backward extending to shortly beyond the base of abdomen; basal three or four segments obscure brownish yellow, succeeding segments black; flagellar segments strongly incised, with verticils that are shorter than the segments; antennæ of female short, the basal seven or eight segments pale, the outer ones darkened; segments very weakly incised to subcylindrical. Head light blue-gray, with a capillary blackish median vitta.

Mesonotal præscutum with ground color light blue-gray, with four slightly darker gray stripes that are narrowly bordered by bright brown, the intermediate pair on outer margin sending a small spur toward the pseudosutural foveæ; scutum light gray, each lobe with two darker gray areas; posterior sclerites of mesonotum light gray, with vague indications of a capillary darker line. The paratopotype has the median præscutal vitta unusually distinct. Pleura clear light gray; dorsopleural membrane pale yellow. Halteres with stem yellow, knobs darkened. Legs with the coxæ whitish gray; trochanters yellow; femora yellow, the tips blackened; tibiæ obscure yellow, the tips more broadly blackened; tarsi black. Wings with the ground color pale yellowish white; cells C and Sc with stigma infuscated; broad and conspicuous brown seams on anterior cord, m-cu, and distal section of Cu_1; a conspicuous pale yellow antestigmal area in cell C; veins brown.

Abdominal tergites with the dorsomedian line ocherous, sparsely pruinose; sublateral stripes broad, on intermediate and outer segments narrowly connected before caudal margins of segments; lateral borders of tergites broadly pale, the caudal margins narrowly so; sternites pale, the subterminal segments infuscated. Male hypopygium with the median plate of tergite (Plate 2, fig. 28, 9*t*) broad, its margin convexly rounded, with a small U-shaped median incision. Outer dististyle, *od,* small, obtusely rounded at tip, the cephalic border near base with long coarse black setæ. Inner dististyle, *id,* with the terminal beaklike portion unusually broad and flattened, the apex obtusely truncated. Gonapophyses, *g,* with the stem long and slender, the blade broader than long. Hair brushes of ninth sternite in four distinct groups.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Tigrovaja, Suchan district, June 9, 1927 (*Stackelberg*), No. 53. Allotopotype, female, June 16, 1927, No. 80. Paratopotype, male, June 9, 1927, No. 54. Paratypes, 1 male, 1 female, Jakovlevka, Spassk district, September 4, 1926 (*Djakonov and Filippjev*), Nos. 123, 176; 1 female, Vladivostok, July 16, 1903 (*Gavronsky*); 1 female, Tiger Mountain, Vladivostok, July 21, 1912 (*Sycheff*), No. 694; 1 female, Maiche region, near Shkotovo, June 4, 1927 (*Sokolov*), No. 576.

The present fly differs conspicuously from *Tipula* (*Tipula*) *morigera* sp. nov. in the structure of the male hypopygium, as shown by the comparative figures. The species is similarly quite distinct in the structure of the male hypopygium from the European *T.* (*T.*) *lateralis* Meigen and *T.* (*T.*) *montium* Egger, which likewise have the basal segments of the flagellum pale. The paratypes have the præscutal stripes more brownish gray and the ground color of the wings more infumed, but certainly appear to belong here.

TIPULA (TIPULA) PROTRUSA sp. nov. Plate 1, fig. 4; Plate 2, fig. 29.

Belongs to the *tricolor* group, allied to *aino;* general coloration gray, the præscutum with four grayish brown stripes that are narrowly bordered by darker brown; antennæ short, scape and pedicel brownish black, the former a little reddish at base; basal flagellar segments with the proximal ends reddish, remainder of organ black; wings strongly infumed, with a conspicuous obliterative area before cord; outer radial cells unbrightened; abdominal tergites unequally trivittate with dark brown; male hypopygium with the tergite produced into a median black plate that is convexly rounded above to appear more or less like a portion of a cylinder.

Male.—Length, 23 to 25 millimeters; wing, 20 to 22; antenna, 3 to 3.3.

Female.—Length, about 25 millimeters; wing, 22 to 23.

Frontal prolongation of head relatively short, reddish brown, pruinose above; palpi black. Antennæ short, if bent backward not attaining the wing root; scape and pedicel brownish black, the former a little reddish at base; first flagellar segment reddish, the succeeding segments black, with the basal enlargements of the proximal segments a little reddish; flagellar segments short and crowded, the verticils subequal to or exceeding the segments. Head gray, the region of the vertical tubercle with a median impressed line.

Mesonotal præscutum gray, with four grayish brown stripes that are narrowly bordered by darker brown, the mesal edges of intermediate stripes a little divided at near midlength to expose a strip of the ground color; scutum blackish gray, the mesal portion of each scutal lobe paler; scutellum brownish gray, bordered by reddish; in cases the scutellum more uniformly gray, with a weak median brown line; mediotergite clear light gray. Pleura with the anterior sclerites clear light gray, the posterior sclerites light yellow, the latter including the pteropleurite, excepting a gray spur at dorsocephalic angle, the dorsal meron, base of halteres, and a stripe across the pleurotergite; dorsopleural membrane more buffy yellow. Halteres pale, the knobs dark brown. Legs with the coxæ light gray, the posterior coxæ a little brightened at bases; trochanters yellow; femora and tibiæ yellow, the tips narrowly black; tarsi black. Wings (Plate 1, fig. 4) strongly infumed, the stigma and costal region somewhat darker; proximal end of stigma yellow; anterior and posterior cord narrowly bordered with brown; obliterative streak before cord conspicuous, extending from before stigma into extreme base of cell M_3; no evidence of paling in outer radial cells, as is the case in *aino;* bases of anal cells a little brightened; veins dark. Venation: Rs from two and one-half to three times m-cu; M_{3+4} from one-third to nearly one-half the basal section of M_3; petiole of cell M_1 about one-half m.

Abdominal tergites broadly buffy dorsomedially, with a broken pale brown median vitta, broadly broken on basal ring, more narrowly so at caudal border of each segment; sublateral stripes darker and more nearly continuous; lateral margins of segments broadly pale; tergal plate of hypopygium dark basally, more reddish outwardly, the median lobe polished black; basal sternites chiefly pale, the subterminal segments heavily gray pruinose. Male hypopygium with the region of tergite (Plate 2, fig. 29, 9*t*) produced medially into a relatively narrow, heavily blackened plate that is convexly arched or rounded so as to appear somewhat like a portion of a cylinder; apex of lobe with a small notch, the lobes thus formed truncated, their outer angles acute; the figure shows the tergal lobe as being more or less flattened and indicates obtuse lateral shoulders. Outer dististyle, *od,* pale, obtuse at apex, the outer margin dilated near base. Inner dististyle, *id,* very complex in structure; on mesal face a sclerotized plate that bears a comb of long reddish spines that are unequally tridentate at tips.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Jakovlevka, Spassk district, June 25, 1927 (*A. Martynov*), No. 214. Allotype, female, in poor condition, Tigrovaja, Suchan district, June 11, 1927 (*Stackelberg*), No. 5. Paratypes, 1 broken male, with allotype, June 8, 1927, No. 59; 1 male, Sedanka River, near Vladivostok, April 20, 1927 (*Martynov*), No. 191; 1 male, Ugodinza River, near Jakovlevka, July 4, 1927 (*Martynov and Rezvoj*), No. 583.

The nearest regional ally of the present fly is *Tipula* (*Tipula*) *aino* Alexander (Japan to Ussuri), which is well-distinguished by the more elongate antennæ, with the basal segments pale, the increased amount of white on the wings, and, especially, the structure of the male hypopygium, notably of the tergal plate.

TIPULA (VESTIPLEX) TUMULTA sp. nov. Plate 1, fig. 5; Plate 2, fig. 30.

Allied to *grahami;* size smaller (wing, male, less than 20 millimeters); mesonotal præscutum dull gray, with four brown stripes, the median line narrowly dark brown; apices of knobs of halteres pale; femora yellow, the tips narrowly black; wings pale brown, variegated by darker brown and whitish areas; basal abdominal segments yellow, narrowly trivittate with dark brown; terminal segments black; male hypopygium with the tergite divided; basistyle with an acute spine.

Male.—Length, about 17 millimeters; wing, 19.5.

Frontal prolongation of head light brown; nasus stout; palpi brown. Antennæ relatively short, ending before wing root; basal four segments obscure yellow, succeeding segments weakly bicolorous, the basal enlargements brown, the remainder brownish yellow; outer segments more uniformly darkened. Head buffy, with a conspicuous brown median line on vertex.

Mesonotal præscutum dull gray, with four brown stripes that are only narrowly and insensibly bordered by darker; a median capillary dark brown line; scutellum grayish yellow, with a median brown line; mediotergite grayish yellow. Pleura chiefly destroyed by crushing, apparently extensively gray. Halteres brownish yellow, the knobs dark brown with pale apices. Legs with the coxæ brownish gray; trochanters yellow; femora yellow, the tips narrowly but conspicuously black; bases of tibiæ obscure yellow, the apices and all tarsi broken. Wings (Plate 1, fig. 5) with the ground color pale brown, variegated by darker brown and whitish areas; prearcular and costal regions light yellow; the darker brown markings include a conspicuous area in the bases of cells R and M, the stigma and a confluent spot on anterior cord, origin of Rs and narrow seams on m-cu and outer end of vein Cu_1; the pale areas are distinctly less yellowish than in *grahami*, being whitish subhyaline, including the axillary region, a broad and nearly complete fascia at near one-third the wing length; other similar areas before stigma, near outer end of cell M and in outer end of cell 1st A; a broad, incomplete, pale crossband beyond cord, extending into base of cell M_3; veins brown, more yellowish in the costal region. Venation: Rs exceeding twice the length of m-cu; vein R_3 gently upcurved at tip, not extended outwardly as in *grahami*, cells R_2 and R_3 at margin being subequal in extent.

Abdomen with the basal segments yellow, the tergites with a median brown line that is narrowly interrupted at the sutures; basal tergites with a similar narrow dark brown sublateral stripe that becomes obsolete beyond the second segment; extreme lateral borders of tergites grayish; segments seven to nine, inclusive, black. Male hypopygium much as in *grahami*. Spines of ninth tergite slender, straight, the surface microscopically roughened. Spine of basistyle, *b*, slender, narrowed to the acute tip. Inner dististyle as shown (Plate 2, fig. 30, *id*).

Habitat.—China (Szechwan).

Holotype, male, Mupin, altitude 3,500 feet (*Graham*).

The nearest ally is *Tipula* (*Vestiplex*) *grahami* Alexander (China-Tibet border) which differs especially in the large size and more yellowish areas of the wing disk. The details of the male hypopygium are slightly different in the two flies, yet so similar as to indicate a close relationship.

TIPULA (VESTIPLEX) JAKUT sp. nov. Plate 1, fig. 6.

General coloration gray, the præscutum with four darker gray stripes that are narrowly bordered by brown; legs relatively short and stout, femora yellowish brown, the tips weakly darkened; wings pale brown, variegated by whitish areas, including all of cells beyond cord excepting the outer radial field; outer medial field pale; m-cu on M_4 some distance beyond origin; abdomen broadly depressed, the tergites obscure yellow, trivittate with dark brown.

Female.—Length, about 22 millimeters; wing, 16.5; hind leg, femur, 7; tibia, 8.8; tarsus, 6.5.

Frontal prolongation of head gray; nasus distinct; palpi dark brown. Antennæ with basal segments obscure yellow, the outer segments darker; outer flagellar segments short and crowded; basal enlargements scarcely developed; verticils a little longer than the segments; terminal segment long. Head light gray; vertical tubercle lacking.

Mesonotal præscutum gray, with four darker gray stripes that are narrowly bordered by brown; interspaces with erect pale setæ; scutal lobes chiefly darkened; posterior sclerites of mesonotum gray. Pleura gray, the dorsopleural region more buffy. Halteres pale, the knobs darkened. Legs with the coxæ pale gray; trochanters reddish yellow; remainder of legs relatively short and stout; femora and tibiæ yellowish brown, their tips weakly darkened; tarsi passing to brownish black. Wings (Plate 1, fig. 6) pale brown, variegated with whitish areas, the ground color including the basal third of wing; stigma a little darker than the ground; the pale areas include the cells beyond cord, excepting the outer half of radial field which is darkened; cell M dark except for a white spot opposite origin of Rs; outer ends of cells Cu and 1st A white, the bases darkened; cell 2d A entirely darkened, veins pale brown. Macrotrichia of veins beyond cord very small and sparse; a scattered series on outer two-thirds of R_{4+5}; M_1, M_2, and M_3 with only a few small trichia; other veins beyond cord glabrous. Venation: Cell M_1 long-petiolate; m-cu on M_4 a considerable distance beyond base; M_{3+4} less than one-half basal section of M_3.

Abdomen broad, depressed, the genital segment abruptly narrowed; ground color of tergites obscure yellow, broadly trivittate with dark brown, the median stripe narrower and more interrupted than the sublaterals; caudal margins of intermediate and outer tergites narrowly pale yellow; sternites reddish brown, sparsely pruinose, the caudal margins of the segments yellow;

dorsal shield of ovipositor blackened; cerci with ill-defined and obtuse teeth, interspersed with setæ.

Habitat.—Eastern Asia (Jakutsk).

Holotype, female, between Ajan and Nelkan, valley of the Tongi River, 137° 30′ east longitude, 56° 40′ north latitude, June 9 to 15, 1903 (*Popov*), No. 442.

The present fly is well distinguished from the other described regional species of *Vestiplex* by the wing pattern, in conjunction with the venation and the depressed abdomen. The latter condition strongly suggests the condition found in certain species of the *besselsi* group occupying this same general region.

TIPULA (ACUTIPULA) OMEIENSIS sp. nov. Plate 1, fig. 7; Plate 2, fig. 31.

General coloration of thorax clear gray, without greenish or olive tints; mesonotal præscutum with four narrow brown stripes, the intermediate pair obsolete in front; femora extensively blackened; wings brown, with broad and conspicuous pale areas along cord and across bases of outer medial cells; male hypopygium with apex of outer lobe of inner dististyle produced at apex into a slender spine.

Male.—Length, about 14 millimeters; wing, 16.5.

Female.—Length, about 21 millimeters; wing, 19.5.

Frontal prolongation of head above reddish yellow, sparsely pruinose, darkened ventrolaterally; nasus stout; palpi black. Antennæ with the scape and pedicel yellow; flagellum black, the first segment brightened at extreme base; verticils of moderate length only, subequal to the segments. Head dark gray.

Mesonotum clear light gray, with no signs of olive or greenish suffusions; præscutum with four narrow brown stripes, the intermediate pair obsolete on cephalic fourth or fifth of sclerite, separated by a median line of the ground color that is subequal to or wider than one stripe; lateral stripes diffuse, best indicated by a slightly darker mesal edge; scutal lobes with darkened areas. Pleura gray; dorsopleural membrane buffy. Halteres black. Legs with the coxæ gray; trochanters yellow; femora of male yellow basally, the tips broadly blackened, the proximal fifth or sixth being brightened; in female, the posterior and middle femora obscure yellow with the tips more narrowly darkened, especially of the hind legs; tibiæ and tarsi brownish black to black. Wings (Plate 1, fig. 7) with a strong brown tinge, the prearcular and costal regions somewhat more brownish yellow; cell Cu on either side of the darkened area and a spot near outer end of cell M light yellow; a distinct, more whitish, obliterative area extending from before the stigma deep into cell M_4, with a continuous brightening that involves the bases of cells M_1, 2d M_2, and M_3, together with the extreme adjoining portion of cell R_5; stigma brown; veins brown. Venation: Rs a little exceeding m-cu, especially in female.

Abdomen with the basal four tergites obscure yellow, trivittate with brown, the remaining segments, including hypopygium, more uniformly darkened; basal sternites yellow. Male hypopygium with the median lobe of tergite entire, set with abundant blackened spicules. Dististyle as shown (Plate 2, fig. 31, *id, od*): Setæ at vertex of inner style very abundant, forty to fifty in number; apex of style produced into a slender spine, with approximately fifteen pendant setæ at and near this spine. Eighth sternite medially not produced into a lobe but provided with abundant long erect yellow setæ.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 11,000 feet, July 19, 1931 (*Franck*). Allotopotype, female, July 18, 1931.

The nearest ally of this fly is *Tipula* (*Acutipula*) *atuntzuensis* Edwards (Yunnan), which differs in the more greenish gray coloration of the head and mesonotum, the distinct nature of the præscutal stripes, and the wing pattern. In the present fly, the outer pale band is very conspicuous, extending from cells R_5 to M_4, inclusive.

TIPULA (ACUTIPULA) VANA sp. nov. Plate 1, fig. 8; Plate 2, fig. 32.

General coloration yellow to pale brown, the præscutum with four brown or reddish brown stripes; pleura yellow; femora yellow, the tips narrowly and weakly darkened; wings with the ground color yellowish, the usual dark pattern relatively pale and ill-defined; spot in cell Cu present; male hypopygium with the median lobe of tergite relatively broad and depressed; eighth sternite at apex produced into a small tubercle, the median region behind this with long erect pale setæ.

Male.—Length, 14 to 15 millimeters; wing, 14.5 to 15.

Female.—Length, 22 to 24 millimeters; wing, 17 to 18.

Frontal prolongation of head light brown; nasus distinct. Antennæ varying from almost uniformly pale yellow to light brownish yellow, with the outer segments passing into brown. Head brownish gray.

Pronotum yellow. Mesonotal præscutum light brown, sparsely pruinose, with four darker brown stripes; in the paratype, the mesonotum has a pale yellow ground, with four more reddish brown stripes; scutum with lobes variegated with reddish brown to pale brown; posterior sclerites of mesonotum chiefly pale. Pleura yellow. Halteres pale yellow, the knobs weakly darkened. Legs with the coxæ and trochanters yellow; femora yellow, the tips narrowly and rather weakly darkened; tibiæ yellow, the tips narrowly darkened; tarsi passing into brown. Wings (Plate 1, fig. 8) with a yellow or pale brownish yellow ground, the prearcular and costal regions light yellow; stigma pale brown; bases of outer radial cells weakly darkened; outer end of cell M and the spot in cell Cu pale brown, relatively indistinct; obliterative band narrow, extending from before stigma into base of cell M_3; veins brown, yellow in the flavous areas. Macrotrichia relatively numerous on veins beyond cord; R_{1+2} with a few trichia near base, in cases almost destitute of same. Venation: Rs and m-cu subequal in length.

Abdomen yellow, the basal tergites narrowly darkened sublaterally; segment five and succeeding segments more uniformly darkened, the caudal margins of segments, especially of the sternites, narrowly but conspicuously ringed with pale. Male hypopygium with the median lobe of tergite (Plate 2, fig. 32, 9*t*) as viewed from above relatively broad and depressed, the apex weakly notched, set with blackened spicules. Outer dististyle pale, narrowed at base, with scattered pale setæ only, with no group of elongate setæ near base, as in *kuzuensis*. Inner dististyle, *id*, with the outer lobe extended into an acute spinous point, before which, on lower face, is a series of about fifteen spines; vertex or crown of style with about forty long erect coarse setæ. Eighth sternite, 8*s*, very moderately sheathing, the apex at midline produced into a small erect to slightly retrorse tubercle that is nearly naked; immediately behind this, the median region of sternite for more than one-half the entire length bears a fringe of long erect pale setæ.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Slavianski Bay, Tulamu River, July 12, 1911 (*Rydzevski and Kuznetzov*), No. 436. Allotopotype, female, with type, No. 437. Paratopotype, male, with type, No. 438; paratype, 1 female, Vladivostok, June 20, 1903 (*Gavronski*), No. 502.

In the unusually pale pattern of the wings, the present fly somewhat resembles the larger *Tipula* (*Acutipula*) *kuzuensis* Alexander, of Japan, which differs in several important features of the male hypopygium, such as the differently shaped outer dististyle, with a brush of elongate setæ on outer margin near base; the obtusely rounded apex of the outer lobe of the inner dististyle; and the lack of a median tubercle on the eighth sternite. This last peculiar feature serves to separate the present fly from other regional generally similar species of *Acutipula.*

TIPULA (ACUTIPULA) COCKERELLIANA Alexander. Plate 3, fig. 33.

Tipula cockerelliana ALEXANDER, Proc. U. S. Nat. Mus. **68**, art. 4 (1925) 14–15.

Described from a single female, taken at Okeanskaja station, near Vladivostok, Ussuri, in August, 1923, by Prof. T. D. A. Cockerell. A few additional specimens now available show that the species is very distinct from all other generally similar described forms.

Okeanskaja, July 27, 1911 (*Shavinskaja*), No. 412; July 31, 1911, No. 410; August 6, 1911, No. 411. Tiger Mountain, Vladivostok, July 21, 1912 (*Sycheff*), No. 692.

The single male from the above series is described as allotype.

Male.—Length, about 20 millimeters; wing, 20.

Characters as in the female, with but few exceptions. Obliterative streak of wing less conspicuous than in type female, but still of unusual width and distinctness. Abdominal segments beyond the third strongly darkened. Male hypopygium with the outer dististyle (Plate 3, fig. 33, *od*) large, narrowed to the subacute apex, the margin, especially near the base, with long conspicuous setæ, those on outer margin before apex very small and sparse; setæ of disk very few and scattered, as is common in the subgenus. Inner dististyle, *id,* as shown; crown or vertex of style with forty or more erect coarse setæ; outer lobe produced at apex into an acute spine that is surrounded by other slightly shorter, more-appressed setæ of similar coarseness; lower lobe or beak blackened, simple. Eighth sternite produced medially and bearing a dense fringe of long yellow setæ that become smaller back from margin.

Allotype.—Okeanskaja station, July 27, 1911 (*Shavinskaja*), No. 412.

The superficial resemblance of this fly to *Tipula* (*Acutipula*) *acanthophora* sp. nov. is surprisingly close, but there is no question of the distinctness and validity of both species.

TIPULA (ACUTIPULA) ACANTHOPHORA sp. nov. Plate 1, fig. 9; Plate 3, fig. 34.

Allied to *Tipula* (*Acutipula*) *cockerelliana;* antennæ relatively short, bicolorous; præscutum gray with four very slightly darker gray stripes; wings pale yellow, with a dark and whitish pattern; obliterative streak broad; pale area across bases of outer median cells not or scarcely entering cell R_5; dark spot in cell

Cu conspicuous; cell 1st M_2 relatively small; male hypopygium with the median lobe of tergite simple, unusually slender; inner dististyle with the outer lobe produced into a long slender spine; eighth sternite with short inconspicuous setæ.

Male.—Length, 17 to 19 millimeters; wing, 20 to 21.

Female.—Length, 22 to 28 millimeters; wing, 20 to 23.

Frontal prolongation of head light brown; nasus conspicuous; palpi brown. Antennæ (male) of moderate length, if bent backward extending to mid-distance between bases of wings and halteres; basal three segments yellow, the remainder bicolorous, chiefly yellow, with the small basal enlargements infuscated; verticils long. Head gray; anterior vertex with a narrow brown line.

Pronotum yellow. Mesonotum light gray, the præscutum with four very slightly darker gray stripes; centers of scutal lobes similarly darkened. Pleura light yellow, the dorsopleural region more buffy. Halteres pale, the bases of knobs dark brown, the tips restrictedly pale. Legs yellow, the tips of femora narrowly brown, of tibiæ even more narrowly infuscated; terminal tarsal segments infuscated. Wings (Plate 1, fig. 9) with the ground color pale yellow, the prearcular and costal regions more saturated yellow; bases of outer radial cells, outer half of cell 1st M_2, and outer end of cell M more darkened; dark spot in cell Cu conspicuous; obliterative streak broad and conspicuous, extending deep into cell M_3 and including the narrow outer border of cell M_4; pale band across bases of outer medial cells not or scarcely invading cell R_5; veins brown, yellow in the flavous areas. Venation: Rs a little longer than m-cu; cell 1st M_2 smaller than in *cockerelliana.*

Abdomen yellow, the outer abdominal segments weakly infumed; basal tergites with scarcely indicated pale brown sublateral stripes. Male hypopygium with the apical point of tergite (Plate 3, fig. 34, 9*t*) unusually slender, simple. Outer dististyle much smaller than in *cockerelliana.* Inner dististyle, *id,* with the outer lobe produced into a slender acute spine; basal lobe compressed, the apex weakly emarginate, the more basal point or beak blackened; crown or vertex of style with approximately eighteen to twenty coarse spinous setæ. Eighth sternite not produced, with short inconspicuous setæ only.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Tigrovaja, Suchan district, August 2, 1927 (*Stackelberg*), No. 6. Allotopotype, female, August 2, 1927, No. 48. Paratopotype, male, August 4 or 5, 1927, No. 83; paratypes, 2 males, Sidemi, July 19, 1897, No. 483; August 18, 1897, No. 451 (*Jankovski*); 1 female, Okeanskaja station, near Vladivostok, July 31, 1911 (*Shavinskaja*), No. 409; 1 female, Kedrovaja Padj, Posjet district, southwest of Vladivostok, June 15, 1926 (*Mordvilko*), No. 616; 1 female, same as last, August 5, 1927 (*Rezvoj*), No. 596.

In its general appearance, the present fly is very similar to *Tipula* (*Acutipula*) *cockerelliana* Alexander, differing most evidently in the structure of the male hypopygium, notably the smaller, less hairy outer dististyle, the acute outer spine of the inner dististyle, and the much shorter and inconspicuous setæ of the eighth sternite. The pale ground color of the wings is less yellowish and the area across the bases of the outer medial cells scarcely invades cell R_5.

TIPULA (LUNATIPULA) VALIDICORNIS sp. nov. Plate 1, fig. 10; Plate 3, figs. 35 to 37.

Belongs to the *fascipennis* group; size large (wing, over 18 millimeters); general coloration of mesonotum yellowish gray, the præscutum with four dark gray stripes; legs yellow, the tips of femora and tibiæ undarkened; wings grayish yellow, the obliterative area very conspicuous; male hypopygium large, the lateral angles of tergite produced caudad into powerful horns; inner dististyle a very narrow blade that is produced into a long spine; eighth sternite sheathing, each lateral angle produced into a tubercle that is tipped with a long reddish spine.

Male.—Length, about 17 to 18 millimeters; wing, 19 to 20.

Female.—Length, about 16 millimeters; wing, 19.

Male.—Frontal prolongation of head brownish yellow, the sides on ventral half somewhat darker; nasus short and stout, with a tuft of long yellow setæ; palpi pale brownish yellow, the terminal segment dark brown. Antennæ moderately long, if bent backward extending to shortly beyond base of abdomen; basal three segments yellow, the outer flagellar segments passing into brown; flagellar segments moderately incised, a little shorter than the longest verticils. Head gray.

Mesonotal præscutum yellowish gray, with four dark gray stripes, the intermediate pair narrowed behind; interspaces with conspicuous yellow setæ; scutal lobes chiefly dark gray; posterior sclerites of mesonotum yellowish gray. Pleura chiefly pale yellow, the ventral anepisternum and ventral sternopleurite gray; dorsopleural region light yellow. Halteres pale, the knobs darkened. Legs with the coxæ yellow, very sparsely pruinose; trochanters yellow; femora and tibiæ obscure yellow, the tips undarkened; tarsi obscure yellow, passing into black. Wings (Plate 1, fig. 10) with the ground color grayish yellow, the prearcular and costal regions, together with cell Cu, clear light yellow; stigma bicolorous, the proximal end yellow, the outer portion brown; outer radial field slightly infumed; narrow dusky clouds on m-cu and distal section of vein Cu_1; a very conspicuous obliterative streak extending from before stigma across cell 1st M_2 almost to wing margin in cells M_3 and M_4, the veins traversed, especially the anterior cord, unusually pale and indistinct; veins brown, more yellowish in the flavous areas. Venation: Cell 1st M_2 slightly more elongate than in the group.

Abdominal tergites yellow, the outer segments, including the hypopygium, more yellowish brown to brown; no distinct stripes on abdomen. Male hypopygium (Plate 3, fig. 35) large and conspicuous; tergite, *9t,* and eighth sternite, *8s,* large, the basistyle and ninth sternite, *9s,* correspondingly reduced; suture between tergite and sternite only faintly indicated. Ninth tergite (Plate 3, fig. 36, *9t*) with each lateral angle produced caudad into a powerful reddish horn, the tip flattened and deflected slightly laterad; base of horn with conspicuous yellow setæ. Basistyle not separated from sternite. Outer dististyle, a tiny lobe, with very long conspicuous setæ. Inner dististyle, *id,* a narrow sclerotized blade that is extended into a slender acute point. Eighth sternite (Plate 3, fig. 36, *8s*) large, the eighth tergite correspondingly reduced; sternite sheathing, each lateral angle of caudal margin produced into a lobe that is tipped with a long reddish spine, these spines decussate across the midline; midventral region of sternite, between lobes, with a brush or fringe of long yellow setæ.

Female.—Characters as in male, differing in sexual features only. Antennæ short, if bent backward scarcely attaining the wing root. Abdominal tergites with a broken median brown line, the sixth and succeeding segments chiefly darkened; sternites pale. Ovipositor with all valves, including cerci, short and blunt (Plate 3, fig. 37, *c*).

Habitat.—Eastern Siberia (Amur, Ussuri).

Holotype, male, Sedanka River, near Vladivostok, Ussuri, April 20, 1927 (*Martynov*), No. 197. Allotopotype, female, with type, No. 196. Paratopotype, male, with type, No. 198. Paratypes, 1 male, Tigrovaja, Suchan district, Ussuri, June 16, 1927 (*Stackelberg*), No. 85; 1 male, Osernaja, mouth of Amur River, June 26 to 28, 1915 (*Chernavin*), No. 711.

The present fly is very distinct from all other Holarctic members of the *fascipennis* (*bicornis*) group in the major size and details of structure of the male hypopygium. The fly is most similar to species such as *affinis* Schummel (Europe) or *bicornis* Forbes, *megaura* Doane, or *parshleyi* Alexander (northeastern North America), but the powerful tergal horns are quite different in position, shape, and direction from the horns of all other described species of the group. It would appear that a new subgeneric group will eventually be required for the members of the group, to be based primarily on the structure of the ovipositor.

TIPULA (LUNATIPULA) PSEUDOGYNE sp. nov. Plate 1, fig. 11; Plate 3, fig. 38.

Belongs to the *fascipennis* group; general coloration gray; antennæ with scape and pedicel yellow, flagellum black; femora yellow, the tips narrowly blackened; wings pale grayish yellow, the costal region clearer yellow; R_{1+2} entire; cell 1st M_2 small; m-cu on M_{3+4} before fork; ovipositor with unusually short cerci, the genital chamber open.

Female.—Length, about 12 millimeters; wing, 12.5.

Frontal prolongation of head relatively short, brown; nasus short and stout; palpi light brown, the terminal segment dark brown. Antennæ with the scape obscure yellow, weakly darkened at base; pedicel light yellow; flagellum black, the basal enlargements poorly defined, the verticils subequal in length to the segments. Head dark brownish gray, the occipital region a little brighter; the area surrounding antennal fossæ pale.

Mesonotum gray, the præscutum without well-defined darker stripes. Pleura gray pruinose, the dorsopleural membrane ocherous. Halteres pale, the knobs weakly infuscated. Legs with the coxæ light gray pruinose; trochanters obscure yellow; femora yellow, the tips narrowly blackened; tibiæ and basitarsi testaceous brown, the outer tarsal segments blackened; tibial spur formula ?–2–2, the fore tibiæ broken. Wings (Plate 1, fig. 11) pale grayish yellow, the prearcular and costal regions clearer yellow; stigma small, pale brown; obliterative areas not conspicuous, lying before stigma and across cell 1st M_2; veins brown. Venation: R_{1+2} entire; R_2 about one-half the last section of R_1; cell 1st M_2 small; m-cu on M_{3+4} before fork.

Abdominal tergites obscure yellow; a conspicuous median black vitta that is narrowly broken at caudal border of segments; sublateral stripes poorly indicated; sternites beyond midlength of second light gray pruinose. Ovipositor (Plate 3, fig. 38) very short and obtuse, at first sight closely simulating the hypopygium of a male; cerci, *c*, short and blunt, as in group. Immediately ventrad of the cerci protrudes a median, depressed, tongue-shaped lobe that is densely clothed with setulæ. A pair of compressed yellow blades, obliquely truncated and coarsely toothed at tips, lie at the outer angles of the ventral region of the genital chamber.

Habitat.—Eastern Siberia (Kamchatka).

Holotype, female, Kamchatka River, 159° east longitude, 56° north latitude, August 11, 1914 (*Bjeloussov*), No. 556. (Hydrographic Expedition to the Pacific.)

In the females of the *fascipennis* (*bicornis*) group, the ovipositor is greatly reduced and but feebly sclerotized, the cerci being blunt and obtusely triangular in outline. The present fly shows this condition unusually developed, the ovipositor thus being of an unusually primitive type. No near ally is known to me, unless, perhaps, it is *Tipula* (*Lunatipula*) *turanensis* sp. nov., which is most readily told by the yellowish ground color of the thorax and the very small cell 1st M_2 of the wings.

TIPULA (LUNATIPULA) TURANENSIS sp. nov. Plate 1, fig. 12; Plate 3, figs. 39–41.

Belongs to the *fascipennis* group; general coloration yellow, the præscutum with three darker stripes that are sometimes poorly indicated; antennæ (male) moderately long, if bent backward extending about to base of abdomen; wings pale grayish yellow, the prearcular and costal regions pale yellow; cell 1st M_2 small, pentagonal; male hypopygium with the ninth tergite bearing conspicuous ventral spines; eighth sternite with lateral tubercles that are tipped with elongate spinous setæ.

Male.—Length, about 12 to 14 millimeters; wing, 13 to 15; antenna, about 4 to 4.5.

Female.—Length, about 13 millimeters; wing, 14.

Male.—Frontal prolongation of head brownish yellow, a little darker laterally beneath; nasus distinct; palpi light brown, the terminal segment dark brown. Antennæ (male) relatively long, if bent backward extending about to the base of abdomen; scape and pedicel yellow; flagellar segments beyond the first almost uniformly brownish black, the basal enlargements a trifle darker; all verticils basal in position, subequal to the segments. Head yellowish brown.

Mesonotal præscutum brownish yellow, with three dark stripes that are dull brownish and, in cases, ill-delimited, the median stripe more or less divided by a capillary pale line; scutal lobes similarly variegated with brown; remainder of notum obscure brownish yellow. Pleura chiefly pale, the sternopleurite and anepisternum somewhat darker. Halteres pale, the central ring of each knob more darkened. Legs with the coxæ and trochanters obscure yellow; femora yellow, the tips weakly darkened; tibiæ and tarsi obscure yellow, the outer tarsal segments a little darker. Wings (Plate 1, fig. 12) pale grayish yellow, the prearcular and costal regions, together with a line between branches of Cu, clear light yellow; stigma bicolorous, the proximal half yellow, the distal half pale brown, the division between the two oblique; obliterative area along cord not unusually wide or conspicuous but involving an unusual number of veins, including all those inclosing cell 1st M_2 with the exception of M_{3+4}, in addition to the anterior cord, outer end of Rs, and the extreme bases of R_{2+3}, R_{4+5}, and outer section of M_{1+2}; veins brown, yellow in the luteous areas. Macrotrichia of veins beyond cord abundant; squama with long conspicuous setæ. Venation: Cell R_2 deep; cell 1st M_2 small, pentagonal; m-cu at or very close to fork of M_{3+4}.

Abdominal tergites brownish yellow, the median line infuscated; sternites more uniformly pale. Male hypopygium (Plate 3, fig. 39) with the tergite, *9t*, entirely separated from the sternite, *9s*; basistyle, *b*, separated from sternite only by a broadly membranous ventral incision. Ninth tergite (Plate 3, fig. 40, *9t*) pale, longer than broad, gently widened outwardly, the caudal margin with a V-shaped notch that is further produced at base into a small rounded incision; lobes of tergite acute or nearly so; ventral-lateral angles of tergite produced caudad into conspicuous sclerotized horns, the blunt tips slightly upcurved. Ninth sternite broadly incised and membranous medially, with two curved hornlike spines in the membrane; dorsocaudal angle of sternite with a stout fingerlike lobe that is tufted with abundant long pale setæ. Dististyle (Plate 3, fig. 40, *d*) single, with a broad flattened blade at posterior angle that is probably the homologue of the outer dististyle. Eighth sternite (Plate 3, fig. 41, *8s*) broad and moderately sheathing, each lateral angle produced into a slender fingerlike lobe that is tipped with a long bristle, this being approximately twice as long as the tubercle itself; besides this spine each tubercle bears additional long pale setæ; median area of sternite between tubercles transverse, fringed with pale setæ that are shorter near the midline, forming two dense groups at this place. The lateral lobes and median fringe are loosely connected by membrane with the actual body of the sternite.

Female.—Characters as in the male, differing in the sexual features. Antennæ much shorter and more nearly unicolorous yellow. Ovipositor with cerci small, roughly triangular in outline; hypovalvæ compressed. Between the valves an acute spine that is directed outwardly.

Habitat.—Eastern Siberia (Amur, Baikal).

Holotype, male, Turan, Baikal; in my collection through purchase from Staudinger-Bang Haas. Allotype, female, Seja River, Amur Province, June 27 to 29 (*Rittig*), No. 640. Paratype, male, Samnjur River, Habarovsk district, Amur, 135° east longitude, 48° 30′ north latitude, July 7 to 11, 1910 (*Stackelberg*).

The unusually small cell 1st M_2 would indicate that this species is highly specialized in the *fascipennis* (*bicornis*) group. It may be readily told from all other regional members, excepting *pseudogyne* sp. nov., by the small size. The yellowish ground color of the thorax and the details of venation, especially the shape of cell 1st M_2, readily separate the present species from *pseudogyne*.

TIPULA MITOPHORA sp. nov. Plate 1, fig. 13; Plate 4, figs. 42, 43.

General coloration gray; præscutum yellowish gray, with four narrow brown stripes; antennæ (male) very long, approximately three-fourths the length of the body; wings tinged with brownish, with a very vague darker and paler pattern that is so diffuse as to give the wing an almost unicolorous appearance; R_2 long, erect; R_{1+2} atrophied beyond the basal spur; male hypopygium with the ninth tergite pale, notched medially.

Male.—Length, 12 to 13 millimeters; wing, 15 to 16; antenna, 9 to 10.

Frontal prolongation of head yellow; nasus distinct; palpi brownish black. Antennæ (male) of unusual length, approximately three-fourths or more of the entire body; basal three segments yellow, succeeding segments bicolorous, the basal enlargements black, the remainder brownish yellow; outer segments passing into brownish black; flagellar segments elongate; verticils much shorter than the segments, those at near midlength of the segments longer than the basal ones; terminal segment reduced to a tiny thimble-shaped structure. Head gray.

Mesonotal præscutum yellowish gray with four narrow brown stripes; intermediate pair widely separated by a line of the ground color, their mesal edges very narrowly and indistinctly bordered by blackish; scutum yellowish gray, the lobes variegated by two confluent brown areas; scutellum dark gray, with a vague blackish median vitta; mediotergite light gray. Pleura gray, the propleura, anepisternum, and sternopleurite clearer gray, the posterior sclerites a little more whitish gray. Halteres pale yellow, the knobs weakly darkened. Legs with the coxæ light gray; trochanters pale yellow; femora obscure yellow, the tips blackened, somewhat more extensively so on forelegs; tibiæ light brown; tarsi black; tibial spur formula 1–2–2; claws small, simple. Wings (Plate 1, fig. 13) tinged with brownish; stigma darker brown; vague brown seams along vein Cu and on anterior cord; a very vague whitish area near outer end of cell M; obliterative area before stigma small and ill-defined; that area across cell 1st M_2 clearly defined. Macrotrichia of veins small but abundant, on all veins beyond cord, including R_2, but excluding m and basal section of M_3. Venation: Tip of R_{1+2} atrophied, only a tiny basal spur being preserved; R_2 unusually long so that R_1 and spur of R_{1+2} are almost in longitudinal alignment; m longer than petiole of cell M_1; m-cu on M_4 some distance beyond origin; cell 2d A of moderate width.

Abdominal tergites orange-yellow to yellow, narrowly trivittate with black, the sublateral stripes very narrow and indistinct on basal half of organ; median stripe continuous and very conspicuous; fifth and succeeding segments more uniformly blackened; basal sternites more uniformly yellowish. Male hypopygium (Plate 4, fig. 42) with the tergite, *9t*, and basistyle, *b*, entirely distinct from the sternite, *9s*. Ninth tergite (Plate 4, fig. 43, *9t*) entirely pale; caudal margin with a V-shaped notch, the base of which is further incised by a smaller quadrate opening; lobes thus formed sublateral in position, obliquely truncated to subacute. Outer dististyle relatively long and slender. Inner dististyle, *id*, with two blackened, beaklike points. Basistyle, *b*, with a group of scattered yellow setæ at ventromesal angle. Ninth sternite rather shallow, incised medially. Eighth sternite unarmed, not projecting.

Habitat.—Eastern Siberia (Amur, Ussuri).

Holotype, male, Cape Dshaore, mouth of Amur River, June 19, 1910 (*Derbeck*), No. 307. Paratopotypes, 5 males, June 17 to 19, 1910, Nos. 306, 308 to 311. Paratype, male, Nikolajevsk, Naleo River, Ussuri, 143° 30′ east longitude, 53° 30′ north latitude, May 1 to 14, 1908 (*Soldatov*), No. 659.

The unusually elongate antennæ of the male sex, together with the atrophied R_{1+2}, mark the present insect as being very distinct from all other regional species. By keys to the European members of the genus, the fly runs to *hortulana* Meigen, an entirely different fly with a distinct wing pattern, short male antennæ, and with the radial venation quite unlike that of the present species.

TIPULA APICISPINA sp. nov. Plate 1, fig. 14; Plate 4, fig. 44.

General coloration of head and thorax light ashy gray, the four præscutal stripes a very little darker gray; antennal flagellum black; halteres yellow, the knobs dark brown; legs black, the femoral bases very narrowly yellow; wings pale brown, the prearcular and costal regions strongly yellow, the disk conspicuously variegated with whitish, including a complete transverse fascia beyond cord; R_{1+2} entire; basal segments of abdomen yellow, the outer segments blackened; male hypopygium with the inner dististyle having the outer basal angle produced ventrad into a conspicuous black spine.

Male.—Length, about 14 millimeters; wing, 15.5; antenna, about 4.

Frontal prolongation of head light brown; nasus distinct; palpi black. Antennæ moderately long, if bent backward extending about to the root of halter; scape and pedicel light yellow; flagellum black, the proximal end of the basal segment a little brightened; basal enlargements of flagellar segments small, the longest verticils subequal to the segments; terminal segment small, thimblelike. Head gray, with a narrow brown median vitta; vertical tubercle distinct.

Mesonotal præscutum light ashy gray, with four scarcely evident darker gray stripes; setæ of interspaces very small, pale; scutum ashy gray, the centers of the lobes vaguely darker gray; scutellum testaceous-brown; mediotergite light gray. Pleura gray, the mesepisternum clearer gray than the posterior sclerites; sternopleurite glabrous. Halteres pale yellow, the knobs dark brown. Legs with the fore and middle coxæ light gray pruinose; posterior coxæ yellow; trochanters yellow; remainder of legs black, the femoral bases very narrowly yellow. Wings (Plate 1, fig. 14) with the ground color pale brown, the prearcular and costal regions strongly yellow; stigma darker brown; disk of wing variegated by whitish, including a complete crossband beyond cord; other conspicuous white areas before cord in cell R_1 and outer end of cell R, near outer end of cell M, base of cell M, most of Cu, and before midlength of 1st A; veins brown. Macrotrichia on most longitudinal veins beyond level of cord; on R_{1+2} only on basal half; lacking on all but last section of vein M_{1+2} and on basal section of M_3; squama naked. Venation; R_{1+2} entire; m subequal to petiole of cell M_1; M_{3+4} subequal to m.

Basal segments of abdomen yellow, the tergites with a narrow darkened median line; fourth and succeeding segments blackened. Male hypopygium (Plate 4, fig. 44) with the tergite, 9*t*, entirely separate from the sternite, 9*s*; basistyle relatively large, cut off from sternite only by a dorsal suture that is more than one-half complete. Ninth tergite, 9*t*, quadrate, the caudal margin nearly transverse, with a small U-shaped median notch that bears a small acute spine at base; dorsal surface of tergite with a median depressed groove back from the spine, this area devoid of trichia. Outer dististyle relatively narrow at base, more expanded at near one-fourth the length, conspicuously setiferous. Inner dististyle, *id*, bidentate at apex, the outer basal angle produced into a long straight spine that is directed ventrad when the style is in a position of rest; outer margin of style below midlength with two, blackened, coarsely toothed plates. Gonapophyses, *g*, blackened, at tips with two unequal black spines that extend in a straight line. Ædeagus stout.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Sedanka, Vladivostok, July, 1913 (*Sycheff*), No. 700. Paratype, a fragmentary specimen, Tigrovaja, Suchan district, August 5, 1927 (*Stackelberg*), No. 61.

Tipula apicispina is most nearly allied to *T. matsumuriana* Alexander (Japan), differing conspicuously in the peculiar structure of the inner dististyle of the male hypopygium, as well as in colorational details, notably the almost unicolorous light gray præscutum and the almost completely blackened femora.

TIPULA MUPINENSIS sp. nov. Plate 1, fig. 15; Plate 4, fig. 45.

General coloration gray, the præscutum with four darker gray stripes, the intermediate pair narrowly margined by dark brown to appear trivittate; antennal scape and pedicel light yellow; femora yellow, the tips not darkened; wings with the ground color brown, variegated by whitish areas, including a narrow, nearly complete fascia beyond cord; R_{1+2} entire; Rs nearly twice as long as m-cu; basal abdominal segments orange-yellow, the outer segments darkened; male hypopygium with the eighth sternite produced medially and densely fringed with yellow setæ.

Male.—Length, about 14 millimeters; wing, 15.5.

Frontal prolongation of head yellowish gray above, darker laterally; nasus lacking or virtually so; basal two segments of palpi brown, the outer segments black. Antennæ of moderate length, if bent backward extending about to wing root; scape and pedicel yellow; flagellum brownish black, the ends of the basal segment paler; longest verticils subequal to the segments. Head brownish gray.

Mesonotal præscutum light gray, with four darker gray stripes, the intermediate pair of which are narrowly bordered by brown, their margins presenting a brown trilineate appearance on the interspaces; posterior sclerites of notum dark gray. Pleura gray, indistinctly variegated with darker gray. Halteres pale yellow, the knobs dark brown. Legs with the coxæ gray; trochanters yellow; femora yellow, the tips not darkened; tibiæ brownish yellow; tarsi passing into brown; tibial spur formula 1–2–2. Wings (Plate 1, fig. 15) with the ground color brown, the prearcular and costal regions strongly yellow; stigma and a confluent cloud on anterior cord darker brown; disk with conspicuous white areas, including a narrow, nearly complete crossband beyond cord, extending from costa nearly to midlength of cell M_3; a broader band before cord, extending from before stigma to vein Cu; a whitish spot in base of cell M; cell Cu chiefly pale, the extreme base and a spot at near midlength remaining of the ground color; anal cells of the ground color; cell 1st A variegated by whitish near base and at margin close to vein 2d A; veins brown, more yellowish in the flavous areas. Venation: R_{1+2} entire, the distal two-thirds without trichia; m and petiole of cell M_1 nearly equal; m-cu on M_4 shortly beyond origin; Rs a little less than twice m-cu.

Basal abdominal segments orange-yellow, the outer segments blackened. Male hypopygium (Plate 4, fig. 45) with the tergite, *9t,* and basistyle, *b,* entirely distinct from the sternite, *9s.* Ninth tergite, *9t,* extensive, the posterior half more narrowed; caudal margin subtruncate to very feebly emarginate, the central portion blackened and produced into a minute median black tooth. Outer dististyle very narrow at base, gradually widened to a triangularly flattened blade. Inner dististyle, *id,* with the outer portion bearing a conspicuous spinous lobe. Membrane of ninth sternite with a group of about a dozen elongate setæ. Gonapophyses, *g,* bispinous. Eighth sternite, *8s,* produced medially into an entire lobe, the caudal margin densely fringed with long yellow setæ, many of which are borne on dorsal surface of sternal plate, remote from margin.

Habitat.—China (Szechwan).

Holotype, male, Mupin, altitude 3,500 feet (*Graham*).

The nearest regional allies of the present fly are *Tipula pedicellaris* Alexander and *T. vivax* Alexander, both from the high mountains of the China-Tibet border. The former has the antennal scape darkened and the femora chiefly black; the latter has the pattern of the præscutum differently arranged and the tips of the femora narrowly and very abruptly blackened.

TIPULA MACROLABIS Loew.

Tipula macrolabis LOEW, Berlin. Ent. Zeitschr. 8 (1864) 58.

This is a common and very widely distributed crane fly in Boreal North America, being known from the Hudsonian and lower Arctic-Alpine zones of Canada from Labrador to Alaska, following southward along the Rocky Mountains to New Mexico (altitude 8,000 to 11,000 feet). Herewith recorded for the first time from the Palæarctic Region.

Kamchatka, Petropavlovsk, 1898 (*Gondatti*). Russian Academy of Sciences No. 588.

TIPULA FORTISTYLA sp. nov. Plate 1, fig. 16; Plate 4, fig. 46.

Belongs to the *flavolineata* group, allied to *curvicauda;* general coloration gray pruinose, the median præscutal stripe polished black; antennæ (male) about one-half the length of body, the basal five segments light yellow, the succeeding segments light brown; femora and tibiæ yellow, the tips narrowly darkened; wings brownish yellow, the prearcular and costal regions bright yellow; stigma brown, its proximal end yellow; male hypopygium with the outer dististyle unusually powerful in structure, strongly curved, its apex weakly notched.

Male.—Length, about 17 millimeters; wing, 19; antenna, about 8.

Frontal prolongation of head light brown; palpi pale yellowish brown to yellow, the apex of basal segment a little darker. Antennæ (male) relatively long, nearly one-half the length of body; basal five segments light yellow, the succeeding segments passing into light brown; flagellar segments elongate, with strong verticils at near midlength, in addition to the basal set, all verticils much shorter than the segments. Head gray, more yellowish on front.

Pronotum gray, more infuscated medially. Mesonotal præscutum with the ground color brownish yellow, pruinose, with three dark stripes, the broad median one black, highly polished, the lateral stripes obscured by pruinosity; posterior sclerites of mesonotum black, heavily gray pruinose. Pleura with anepisternum and sternopleurite light blue-gray, the posterior sclerites much paler, more whitish; dorsopleural membrane pale yellow. Halteres with slender stems and small knobs, pale yellow, the knobs infuscated. Legs with the coxæ light gray; trochanters yellow; femora yellow, the tips very narrowly but conspicuously brownish black; tibiæ yellow, the tips very narrowly darkened; tarsi black, the basitarsi darker at proximal ends; claws (male) with a small basal spine. Wings (Plate 1, fig. 16) tinged with brownish yellow, the costal and prearcular regions bright yellow; stigma brown, its proximal end light yellow; a poorly defined brown cloud on anterior cord; obliterative areas restricted, lying before stigma and across base of cell 1st M_2, interrupted at junction of r-m with R_5; veins brown, brighter in the yellow areas. Venation: R_{1+2} and R_3 divergent; fork of M_{3+4} lying proximad of r-m; cell 2d A narrow.

Abdominal tergites yellow, becoming more obscure and slightly pruinose beyond basal third of organ; outer segments more infuscated; intermediate tergites with caudal and sublateral portions slightly darkened, the lateral borders pale; second tergite with a brown ring beyond midlength; sternites more infuscated, brighter caudally and laterally; hypopygium brownish black. Male hypopygium (Plate 4, fig. 46) with the tergite entirely separate from the sternite; basistyle, *b*, very large, chiefly fused with sternite, indicated by a ventral suture. Ninth tergite, 9*t*, with the lateral lobes obtuse; submedian teeth slender, directed slightly toward one another, separated only by a narrow notch. Outer dististyle, *od*, constructed much as in *curvicauda* but shorter and stouter, more strongly curved; at apex with a weak notch that is densely set with erect pale setulæ. Inner dististyle, *id*, as shown. Ninth sternite tumid, the two sides separated by a narrow V-shaped notch, each half with abundant erect setulæ. Eighth sternite unarmed.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Vladivostok, June 27, 1907 (*Smirnov*), No. 651.

The present fly belongs to the *flavolineata* group, being closest to *Tipula curvicauda* and *T. issikii*, from both of which it is readily told by the shorter antennæ of the male, with the basal flagellar segments extensively pale, and by the structure of the male hypopygium, especially the very short and stout, strongly curved, outer dististyle.

The *flavolineata* group includes, besides *flavolineata* Meigen (Europe), four Japanese species (*curvicauda* Alexander, *dichroistigma* Alexander, *issikii* Alexander, and *nigrosignata* Alexander), together with the present fly. The various members of the group agree in the unusually elongate antennæ of the male and in the general structure of the ninth tergite of the male hypopygium, the caudal margin of which is emarginate and provided with two small submedian blackened teeth at base of notch. *Tipula flavolineata* and *T. dichroistigma* have the præscutum pruinose, but the other species have it more or less polished black, sometimes very conspicuously so. *Tipula flavolineata, T. dichroistigma,* and *T. nigrosignata* have the outer dististyle small and relatively insignificant, but still more or less arcuate and differing in conformation from the organ in the other members of the genus; *T. curvicauda, T. issikii,* and *T. fortistyla* have the outer dististyle very large and powerfully constructed.

Edwards[2] did not assign *flavolineata* to any of the subgenera that he defined, and I hesitate to attempt such an assignment at this time, though with more numerous species before me. All species have the nasus elongate; R_{1+2} entire; fork of M_{3+4} unusually close to the base of cell 1st M_2, as in the *tricolor* group of the subgenus *Tipula,* lying slightly proximad of r-m; macrotrichia of veins beyond cord small and relatively sparse; squama naked. Tibial spur formula 1–2–2. Male hypopygium with the tergite entirely separate from the sternite; basistyle large, cut off only by a ventral suture.

The somewhat similar but not closely allied *juncea* (*pribilofensis*) group is likewise eminently characteristic of the boreal portions of the Holarctic region. Its affinities seem to lie closer to *Vestiplex,* but it seems highly probable that a new subgeneric group will be required for the reception of the included species.

LIMONIINÆ

PEDICIINI

PEDICIA (TRICYPHONA) USSURICA sp. nov. Plate 1, fig. 17; Plate 4, fig. 47.

Allied to *unicolor;* general coloration gray, the præscutum with four conspicuous blackish stripes; antennæ black throughout, 14- or 15-segmented, the flagellar segments short and crowded; halteres uniformly pale yellow; femora obscure yellow basally, the tips brownish black, broadest on forelegs; wings pale yellow, the prearcular region clear light yellow; pale brown seams along cord; venation very variable, r-m connecting at or beyond fork of Rs; cell 1st M_2 elongate, closed; male hypopygium with the lateral angles of tergite produced into short glabrous arms; interbase weakly notched at apex.

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[2] Ann. & Mag. Nat. Hist. X 8 (1931) 82.

Male.—Length, about 7.5 to 8 millimeters; wing, 7.5 to 8.

Female.—Length, about 8 to 9 millimeters; wing, 8 to 8.5.

Rostrum and palpi black. Antennæ short, black throughout; segments varying in number from fourteen to fifteen, the outer ones very short and crowded. Head dark gray; vertical tubercle small.

Pronotum dark gray. Mesonotal præscutum light gray, with four conspicuous blackish stripes, the intermediate pair nearly confluent at anterior ends; scutum gray, each lobe variegated by two blackish areas; posterior sclerites of mesonotum dark gray. Pleura dark gray; dorsopleural membrane brown. Halteres uniformly pale yellow. Legs with the coxæ dark gray; trochanters yellow; femora obscure yellow basally, the tips brownish black, broadest on the forelegs where about two-thirds to three-fourths is included, very narrow on the middle and posterior legs where only the distal fourth or fifth is darkened; tibiæ dark brown, the posterior tibiæ much brighter, narrowly tipped with dark brown; tarsi black. Wings (Plate 1, fig. 17) with the ground color pale yellow, the prearcular region clear light yellow; narrow but conspicuous pale brown seams on anterior and posterior cords, narrowly interrupted at the fork of M; stigma very pale to lacking; veins brown, light yellow in the prearcular region. Venation: Sc_2 before origin of Rs a distance about equal to one-third to one-half the length of Rs, the latter somewhat variable in length, angulated at origin; petiole of cell R_4 variable, in cases exceeding r-m, in other instances shorter than this element; r-m connecting with R_{4+5} before midlength, sometimes as far proximad as the end of Rs; cell 1st M_2 elongate; m variable in position, from opposite the fork of M_{1+2} to some distance before this fork, in the latter case (as figured) m being shorter than the petiole of cell 1st M_2; m-cu likewise variable in position, from being placed at the fork of M_{3+4} to some distance before this fork, in cases before midlength of M_{3+4}.

Abdominal tergites dark brown, the caudal margins of the intermediate segments very narrowly yellow; basal sternite dark, the intermediate ones pale brown, the outer segments again darkened. In female, abdomen more uniformly dark brownish gray; ovipositor large, powerfully constructed, horn yellow. Male hypopygium (Plate 4, fig. 47) with the tergite, *9t*, broad, the caudal margin very shallowly emarginate, the lateral angles produced caudad and laterad into short glabrous horns; median region of tergite densely setiferous. Basistyle, *b*, divided at apex into two lobes, the broader one densely set with very numerous small blackened pegs that present an unusually uniform arrangement; inner lobe of basistyle very small, slender, pale, with coarse setæ. A single dististyle, *d*, which is subequal in length and size to the inner apical lobe of basistyle; lower margin at base fringed with about six elongate setæ, with smaller setæ near apex. Interbase, *i*, a powerful curved rod, light yellow, the apex shallowly and unequally bidentate, the surface near base with numerous fine setæ.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Maiche region, near Shkotovo, June 5, 1927 (*Martynov*), No. 208. Allotype, female, Tigrovaja, Suchan district, June 16, 1927 (*Stackelberg*), No. 34. Paratopotypes, one of each sex, with type, Nos. 204, 209.

The present fly is most nearly related to Japanese species such as the much larger *Pedicia* (*Tricyphona*) *optabilis* (Alexander), differing most evidently in the wing pattern and details of structure of the male hypopygium. Among the European species, it is more distantly allied to species such as *P.* (*T.*) *schummeli* (Edwards) and *P.* (*T.*) *unicolor* (Schummel), differing from both in the diagnostic features listed, the most evident being the closed cell 1st M_2 and the pale brown but distinct clouding along cord of wing.

HEXATOMINI

LIMNOPHILA (LIMNOPHILA) SOLDATOVI sp. nov. Plate 1, fig. 18.

General coloration light gray, the præscutum with scarcely indicated darker gray stripes; halteres uniformly pale yellow; legs yellow, the tips of femora narrowly blackened, the amount subequal on all legs; wings with the ground color whitish, heavily patterned with dark brown, including four broken fasciæ and scattered smaller dots in interspaces; m-cu at near midlength of cell 1st M_2.

Female.—Length, 15 to 17 millimeters; wing, 10.5 to 11.5.

Rostrum gray; palpi brownish black. Antennæ with the scape and pedicel black, heavily dusted with gray; flagellum pale yellowish brown, the outer segments darker; basal segments large, the outer segments more slender, with long conspicuous verticils. Head clear light gray, prolonged behind.

Pronotum massive, light gray. Mesonotal præscutum clear gray with four scarcely evident darker gray stripes, the extreme cephalic portions of the intermediate pair blackened, appearing as if the pruinosity were denuded, but the appearance is quite the same in all specimens of the series; pseudosutural foveæ black, triangular, large and conspicuous; tuberculate pits lacking; posterior sclerites of notum clear light gray, the centers of the scutal lobes very vaguely darkened. Pleura gray, the dorsopleural region light brown. Halteres uniformly pale yellow. Legs with the coxæ light gray; trochanters yellow; femora yellow, the tips narrowly blackened, the amount subequal on all legs and including about the outer sixth or less; tibiæ obscure yellow, the bases narrowly, the tips a little more broadly, blackened; tarsi black; legs conspicuously hairy. Wings (Plate 1, fig. 18) with the ground color whitish, with a heavy brown pattern arranged as four more or less broken crossbands, with scattered smaller brown dots in the interspaces; basal fascia postarcular, extending from C to Cu; second band at level of origin of Rs, broadly broken at cell M; third fascia at cord, forking at costa and inclosing a small yellow area beyond Sc_2; last band including the narrow wing apex, in cases extending from tips of veins R_3 to M_4, in other instances the two latter areas separate from the main apical mass; dots in interspaces sparse, lacking in the basal radial field, elsewhere more or less restricted to the vicinity of the veins; veins brown, more yellowish in the interspaces. Macrotrichia of veins relatively sparse, lacking on R_{2+3+4}, R_{2+3}, R_3, or R_4; a scattered series on distal section of R_5, more crowded at outer end; outer medial branches with sparse scattered trichia. Venation: R_{2+3+4} short to very short; fork of cell M_1 short; m-cu at or close to midlength of cell 1st M_2; anterior arculus preserved.

Abdomen clear light gray, the extreme caudal portions of the segments ringed with pale brown; narrow black transverse impressions on basal rings of segments, with more widely separated oblique dashes on posterior rings. Ovipositor dark reddish brown, the tips of cerci narrowly pale.

Habitat.—Eastern Siberia (Ussuri).

Holotype, female, Osernaja, mouth of Amur River, June 12 to 25, 1910 (*Soldatov*), No. 666. Paratopotypes, 1 female, with the type; 1 female, May 31, 1910, Nos. 665, 667.

This interesting crane fly is named in honor of Mr. W. Soldatov, who has collected numerous Tipulidæ near the mouth of the Amur and on Saghalien Island. The nearest ally is *Limnophila (Limnophila) martynovi* Alexander, which agrees in the general features of structure and coloration, as the uniformly pale halteres and the reduced trichiation of the wings. Apart from the venational peculiarities of *martynovi*, as the loss of crossveins m and m-cu, features which may prove to represent abnormalities of the unique type, the present fly differs in the pale antennal flagellum; indistinct tuberculate pits; narrowly blackened femora, with the degree of darkening nearly equal on all legs; and the more fully developed wings. These two species differ from the other regional members of the subgenus in the uniformly pale halteres.

LIMNOPHILA (LIMNOPHILA) POLITOSTRIATA sp. nov. Plate 1, fig. 19; Plate 4, fig. 48.

General coloration of thorax light gray, the præscutum more yellowish gray, with four, narrow, polished, black stripes; knobs of halteres dark brown; femora yellow, the tips narrowly blackened; tibiæ yellow, the extreme bases and tips darkened; wings whitish subhyaline, heavily patterned with brown; abdomen black, sparsely pruinose; male hypopygium with the outer angle of basistyle produced into a smooth blackened spine.

Male.—Length, about 10 millimeters; wing, 10.

Female.—Length, about 11 to 14 millimeters; wing, 9.5 to 11.

Rostrum gray; palpi black. Antennæ black throughout; in male relatively short, if bent backward ending some distance before wing root; verticils long and conspicuous. Head light gray.

Pronotum massive, light gray. Mesonotal præscutum yellowish gray with four, intense black, highly polished stripes, the intermediate pair narrowly separated by a capillary line of the ground color, not attaining the suture; lateral stripes crossing the suture and covering almost all of scutal lobes; pseudosutural foveæ conspicuous, black, triangular in outline; remainder of mesonotum light gray, the scutellum broad. Pleura light gray; dorsopleural region brown. Halteres pale yellow, the knobs infuscated. Legs with the coxæ light gray pruinose; trochanters dark brown; femora yellow, the tips narrowly blackened, the amount subequal on all legs, involving the outer sixth or seventh; tibiæ light yellow, the very narrow bases and very little wider tips blackened; tarsi light brown, the outer segments darker. Wings (Plate 1, fig. 19) whitish subhyaline, the costal region concolorous; a heavy dark brown pattern, appearing as about four or five major costal areas, marginal spots at ends of all longitudinal veins and numerous small dots in all cells, almost lacking in the radial field; the two largest costal areas, lying at origin of Rs and in stigmal region, are more or less Y-shaped, the fork inclosing a tiny pale costal spot; veins yellow, darker in the clouded areas. Macrotrichia on outer ends of veins beyond cord, including R_4, all of R_5, and distal ends of outer medial veins; anterior branch of Rs without trichia. Venation: Rs elongate, arcuated to angulated and spurred at origin; R_{2+3+4} very short; R_{1+2} and R_2 subequal; cell M_1 shorter than its petiole; m-cu at or close to fork of M; anterior arculus preserved.

Abdomen black, the surface sparsely pruinose; hypopygium black. Male hypopygium (Plate 4, fig. 48) with the outer apical angle of basistyle, *b*, produced into a slender smooth blackened spine. Ædeagus, *a*, and gonapophyses, *g*, elongate, the latter pale in color.

Habitat.—Eastern Siberia (Ussuri, Saghalien).

Holotype, male, Osernaja, mouth of Amur River, Ussuri, June 24, 1915 (*Chernavin*), No. 716. Allotype, female, Kuegda, Saghalien Island, July 10, 1908 (*Soldatov*), No. 687. Paratopotype, female, Osernaja, June 28, 1908 (*Soldatov*), No. 671. Paratype, female, Cape Pronge, mouth of Amur River, 141° 15′ east longitude, 53° north latitude, June 24, 1910 (*Derbeck*), No. 314.

Limnophila (*Limnophila*) *politostriata* is very different from the other known members of the typical subgenus *Limnophila* (*Pœcilostola*) in the very distinct præscutal stripes and acute blackened spine of the basistyle of male hypopygium. The other generally similar regional members either have the basistyle unarmed (*japonica* Alexander, *varicornis* Coquillett) or else have the outer lobe of basistyle pale and not constructed as a glabrous spine (*pictipennis* Meigen).

HEXATOMA (ERIOCERA) ÆQUINIGRA sp. nov. Plate 1, fig. 20.

Belongs to the *spinosa* group; mesonotal præscutum yellowish gray, with four narrow dark brown stripes, the intermediate pair separated by a grayish line that is slightly wider than the stripes; setæ of thorax unusually long and pale for the female sex; knobs of halteres dark brown; femora yellow, with the distal sixth or less blackened, the amount subequal on all legs; wings brownish yellow; stigma small, dark brown; macrotrichia on veins R_{2+3}, R_3, and distal two-thirds of R_4; cell M_1 present; abdomen dark brown, the tergites margined laterally with orange.

Female.—Length, about 33 millimeters; wing, 23.

Rostrum light brown; palpi dark brown. Antennæ with the scape and pedicel dark brown above, paler beneath; flagellum broken. Head brownish gray, reddish on either side of midline of vertical tubercle; setæ long and dense.

Mesonotal præscutum yellowish gray, the lateral interspaces suffused with light brown; four narrow dark brown stripes, the intermediate pair separated by a grayish line that is a little wider than either stripe; pubescence of notum white, unusually long and dense for the female sex; scutum grayish, each lobe with a large dark area; scutellum dark, the margin fringed with long yellow setæ; mediotergite gray, darker caudally. Pleura clear light gray, the dorsopleural region variegated with dark brown and buffy; setæ of propleura long and conspicuous, pale. Halteres light yellow, knobs dark brown. Legs with the coxæ light gray, clothed with long pale setæ; trochanters yellow; femora yellow, the tips of all legs narrowly blackened, the amount subequal on all legs, including approximately the distal sixth or less; tibiæ reddish brown, the tips narrowly blackened; tarsi reddish brown, the outer segments black. Wings (Plate 1, fig. 20) tinged with brownish yellow; stigma small, dark brown; vague dusky washes along Rs, Cu, and 2d A; veins chiefly dark brown, Sc and most of M more yellowish. Macrotrichia of veins unusually abundant for a member of this group; series of trichia on entire length of R_{2+3} and R_3, and on about the distal two-thirds of outer section of R_4, the latter series including from twenty-five to thirty punctures; trichia on R_5 sparse and scattered; no trichia on outer medial veins. Venation: R_{2+3} a little shorter than R_3; Rs in alignment with R_5; m-cu before midlength of cell 1st M_2.

Abdomen dark brown, the sternites sparsely pruinose; lateral margins of tergites narrowly but conspicuously orange; tergites each with four transverse blackened impressions on basal ring. Ovipositor with the elongate valves deep cherry red.

Habitat.—Eastern Siberia (Ussuri).

Holotype, female, Tigrovaja, Suchan district, August 2, 1927 (*Stackelberg*).

The nearest ally of this fly is *Hexatoma* (*Eriocera*) *stricklandi* (Edwards), of Japan, which differs in the much paler wings, three dark præscutal stripes, and unequally blackened femora, the posterior femora being much more extensively darkened than are the other two pairs. The present fly further differs from most of the other regional members of the group in the rather unusual degree of trichiation of the wing veins, there being a series on more than the distal half of vein R_4, which, in most of the other species of the *spinosa* group, is quite glabrous.

HEXATOMA (ERIOCERA) ATRIPES sp. nov. Plate 1, fig. 21.

Belongs to the *spinosa* group; general coloration brownish black; antennæ and legs black throughout; mesonotal præscutum with the lateral stripes narrow, polished; wings tinged with brown; macrotrichia on radial veins beyond cord.

Female.—Length, about 25 millimeters; wing, 18.3 by 5; antenna, 6.

Rostrum brownish black; palpi black. Antennæ 11-segmented, black throughout; flagellar segments gradually decreasing in length to end. Head broadly blackened on vertex, the lateral portions behind eyes paling to brown.

Mesonotal præscutum with the interspaces heavily pollinose with buffy; three stripes, the broad median one dull black, further divided by a deeper black median vitta that narrows to a point behind at suture; lateral stripes narrow, polished black; scutum brown, the lobes variegated by subnitidous darker brown areas; scutellum and mediotergite dark brown, very sparsely yellow pollinose. Pleura chiefly dark brown, the dorsal sternopleurite and most of pleurotergite paler. Halteres with the stem obscure yellow, the knobs blackened. Legs with the coxæ black, gray pruinose; trochanters reddish brown; remainder of legs entirely black. Wings (Plate 1, fig. 21) with a strong brown tinge, the costal region slightly darker; stigma oval, darker brown; veins dark brown. Macrotrichia on all radial veins beyond cord excepting R_{1+2} and R_2. Venation: R_{1+2} nearly three times R_2; R_{2+3+4} shorter than R_{2+3}; cell M_1 shorter than its petiole.

Abdominal tergites brownish black, the sternites a little paler; genital segment brownish gray pruinose. Cerci elongate, blackened, basally, paling to reddish at tips.

Habitat.—Eastern Siberia (Ussuri).

Holotype, female, Vinogradovka, 133° 50′ east longitude, 43° 20′ north latitude, August 5, 1929 (*Djakonov*), No. 531.

Hexatoma (*Eriocera*) *atripes* is readily distinguished from all other described members of the *spinosa* group by the uniformly blackened legs.

HEXATOMA (ERIOCERA) USSURIENSIS sp. nov. Plate 1, fig. 22; Plate 4, fig. 49.

Belongs to the *verticalis* group; size large (wing, male, 15 millimeters or more); general coloration gray, the præscutum with four more-blackened stripes; antennæ (male) elongate;

vertical tubercle obscure yellow, polished black at summit; femora yellow, the tips very narrowly blackened, the amount subequal on all legs; wings with a faint brownish tinge, the oval stigma darker brown; m-cu close to fork of M.

Male.—Length, 11 to 12 millimeters; wing, 15 to 16; antenna, about 44 to 46; length of flagellar segment 1, 6 millimeters; segment 2, 7.6; segment 3, 7.5.

Female.—Length, 14 to 15 millimeters; wing, 13 to 14.5; antenna, about 3.8.

Rostrum pale brown; palpi black. Antennæ of male with the scape very large, yellow beneath, darker above; pedicel very small, brown; flagellum black; segments with conspicuous erect spines that are arranged in two rows; first flagellar segment with about twenty spines in each row, second segment with about twenty-eight, third segment with about twenty-one such spines, on outer segments becoming more scattered but fully as large and strong. Antennæ of female 11-segmented, the basal three or four segments pale, the remainder black. Head brownish gray, the conspicuous vertical tubercle yellow, its summit polished black.

Mesonotal præscutum gray, with four more-blackish stripes, the intermediate pair being widely separated by the ground color; thorax with dense erect white pubescence in male, nearly glabrous in female; posterior sclerites of notum, together with the pleura, gray. Halteres pale yellow, the knobs dark brown. Legs with coxæ darkened and sparsely pruinose, paler at tips; trochanters obscure yellow; femora yellow, the extreme tips blackened, the amount subequal on all legs; tibiæ obscure yellow, the tips narrowly dark brown, subequal in degree to the femoral darkening; basitarsi light brown, the tips and remainder of tarsi passing into dark brown. Wings (Plate 1, fig. 22) larger and broader in male, with a very faint brown tinge, the costal portion more yellowish; stigma darker brown, oval, conspicuous; cord narrowly seamed with brown, the longitudinal veins less distinctly so; veins dark brown, Sc more yellowish. Venation: R_{2+3}, R_2, and R_{1+2} all subequal; m-cu close to fork of M, in cases a trifle before or beyond this point.

Abdominal tergites dark brown, the caudal margins of segments more blackened; sternites more variegated, obscure brownish yellow basally and laterally, the caudal margins of the segments darker. Male hypopygium (Plate 4, fig. 49) with the inner dististyle, *id*, broad. Gonapophyses, *g*, bifid, one arm spinous, the other unusually broad and flattened. Ovipositor with the genital shield and elongate valves reddish horn-color.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Bikin, River Bikin, 134° 10′ east longitude, 46° north latitude, July 10, 1927 (*Martynov*), No. 563. Allotopotype, female, No. 568. Paratopotypes, 3 of both sexes, July 8 to 12, 1927, Nos. 564, 565, 602. Paratype, female, River Zeja, near town of Blagoveshtshensk, June 3, 1927 (*Martynov*), No. 599.

Hexatoma (*Eriocera*) *ussuriensis* is most closely allied to *H.* (*E.*) *gifuensis* Alexander (Japan), from which it differs in the conspicuously larger size in both sexes, the more broadly darkened femoral tips, and slight hypopygial distinctions.

ERIOPTERINI

RHABDOMASTIX (SACANDAGA) USSURICA sp. nov. Plate 1, fig. 23.

General coloration light yellow, the præscutum with three pale brown stripes, the median one darker in front; antennæ with the scape yellow, the remaining segments black; wings pale yellow, the veins pale brown; R_{1+2} and R_3 not widely separated at margin.

Male.—Length, about 3.5 millimeters; wing, 3.8.

Rostrum yellow; palpi brown. Antennæ with the scape light yellow; pedicel and flagellum dark brown; antennæ relatively long, if bent backward ending some distance before wing root. Head light yellow.

Mesonotum yellow, the præscutum with three pale brown stripes, the median one darker in front. Pleura clear yellow. Halteres pale, the knobs weakly darkened. Legs yellow throughout. Wings (Plate 1, fig. 23) pale yellow, the costal margin a little more suffused; veins pale brown. About six macrotrichia on central half of vein R_4; a series on almost entire length of outer section of R_5; outer branches of M with macrotrichia except on basal ends; Cu and anal veins naked. Venation: Sc_1 ending at near three-fourths the length of Rs; R_3 separated from R_{1+2} along costa by a distance less than its length; outer section of M_{1+2} unusually flaring as it leaves cell 1st M_2; m-cu beyond midlength of lower face of cell 1st M_2; basal section of M_{3+4} short to very short; cell 2d A relatively narrow.

Abdomen obscure yellow, the hypopygium clearer yellow.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Tigrovaja, Suchan district, August 4, 1927 (*Stackelberg*), No. 24.

Rhabdomastix (*Sacandaga*) *ussurica* is very different from the only other member of the genus so far recorded from eastern Siberia, *R.* (*S.*) *usuriensis* Alexander,[3] which is black, with strongly infumed wings and with bright yellow knobs to the halteres. Other Holartic species that are generally similar in coloration to the present fly—such as *R.* (*S.*) *læta* (Loew), of Europe; *R.* (*S.*) *japonica* Alexander, of Japan; and *R.* (*S.*) *flava* Alexander, of North America—are all readily told by the much larger size. The present fly is one of the smallest species of the genus so far made known.

ORMOSIA CHANKANA sp. nov. Plate 1, fig. 24; Plate 4, fig. 50.

Belongs to the *bivittata* group; general coloration brown, the præscutum with two dark brown submedian stripes that cross the suture onto the scutal lobes; antennæ short in both sexes, black throughout; knobs of halteres dark brown; wings with a strong brown tinge, with a small, slightly darker cloud on anterior cord; male hypopygium with both dististyles elongate, the inner one subacute at tip.

Male.—Length, about 4 millimeters; wing, 4.8.

Female.—Length, about 5 millimeters; wing, 5.8.

Rostrum and palpi dark brown. Antennæ brownish black throughout, short in both sexes but a little longer in male; flagellar segments oval. Head dark brown.

Mesonotal præscutum light brown with two dark brown submedian stripes that are only narrowly separated by a ground vitta, a little divergent behind and crossing the suture onto the mesal edge of the scutal lobes; lateral stripes of præscutum represented only by dusky suffusions near suture; pseudosutural foveæ and tuberculate pits black, conspicuous; setæ of interspaces black, erect; scutum with median area broadly light brownish testaceous; scutellum pale, with a small brown median spot; mediotergite brownish gray. Pleura chiefly brown, more yellowish on posterior portion. Halteres pale, the knobs dark brown. Legs with the coxæ pale grayish brown; trochanters yellow; remainder of legs light brown or brownish yellow, the femoral tips weakly darkened; outer tarsal segments brown; in the male the legs are somewhat darker brown. Wings (Plate 1, fig. 24) with a strong brown tinge; stigma lacking; a slightly darker brown cloud on anterior cord; veins and macrotrichia darker brown. Venation: Sc_1 ending beyond fork of R_{2+3+4}, Sc_2 shortly before midlength of Rs; cell 1st M_2 small, widened outwardly, the second section of M^{1+2} from about two-fifths to one-third the last section; m-cu at fork of M.

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[3] Proc. U. S. Nat. Mus. 68, art. 4 (1925) 13.

Abdomen dark brown. Male hypopygium (Plate 4, fig. 50) with the basistyle, *b*, relatively long. Both dististyles long and slender, the outer, *od*, microscopically roughened at apex and along outer margin almost to base; inner dististyle, *id*, pale, narrowed to the subacute tip, the outer margin with a pale bituberculate flange.

Habitat.—Eastern Siberia (Ussuri).

Holotype, female, Kamen-Rybolov, Lake Chanka, 132° east longitude, 44° 15′ north latitude, July 8, 1927 (*Stackelberg*). Allotopotype, a damaged male.

The only closely allied species known to me are the western Palæarctic *Ormosia bivittata* (Loew) and the Nearctic *O. hubbelli* Alexander. The type of hypopygium, which is very distinct from all other *Ormosia* species known to me in the elongate dististyles and lack of a modified tergal plate, is very similar in all three species, even to the bituberculate flange on the inner dististyle. The subacute inner dististyle, armature of the outer dististyle, and the details of venation of the present fly are sufficiently distinct. I have selected the well-preserved female specimen as type in preference to the badly damaged male.

ILLUSTRATIONS

[*a*, Ædeagus; *b*, basistyle; *c*, cercus; *d*, dististyle; *g*, gonapophysis; *i*, interbase; *id*, inner dististyle; *od*, outer dististyle; *p*, phallosome; *s*, sternites; *t*, tergites.]

PLATE 1

FIG. 1. *Tipula* (*Tipula*) *stackelbergi* sp. nov., venation.
2. *Tipula* (*Tipula*) *subsulphurea* sp. nov., venation.
3. *Tipula* (*Tipula*) *morigera* sp. nov., venation.
4. *Tipula* (*Tipula*) *protrusa* sp. nov., venation.
5. *Tipula* (*Vestiplex*) *tumulta* sp. nov., venation.
6. *Tipula* (*Vestiplex*) *jakut* sp. nov., venation.
7. *Tipula* (*Acutipula*) *omeiensis* sp. nov., venation.
8. *Tipula* (*Acutipula*) *vana* sp. nov., venation.
9. *Tipula* (*Acutipula*) *acanthophora* sp. nov., venation.
10. *Tipula* (*Lunatipula*) *validicornis* sp. nov., venation.
11. *Tipula* (*Lunatipula*) *pseudogyne* sp. nov., venation.
12. *Tipula* (*Lunatipula*) *turanensis* sp. nov., venation.
13. *Tipula mitophora* sp. nov., venation.
14. *Tipula apicispina* sp. nov., venation.
15. *Tipula mupinensis* sp. nov., venation.
16. *Tipula fortistyla* sp. nov., venation.
17. *Pedicia* (*Tricyphona*) *ussurica* sp. nov., venation.
18. *Limnophila* (*Limnophila*) *soldatovi* sp. nov., venation.
19. *Limnophila* (*Limnophila*) *politostriata* sp. nov., venation.
20. *Hexatoma* (*Eriocera*) *æquinigra* sp. nov., venation.
21. *Hexatoma* (*Eriocera*) *atripes* sp. nov., venation.
22. *Hexatoma* (*Eriocera*) *ussuriensis* sp. nov., venation.
23. *Rhabdomastix* (*Sacandaga*) *ussurica* sp. nov., venation.
24. *Ormosia chankana* sp. nov., venation.

PLATE 2

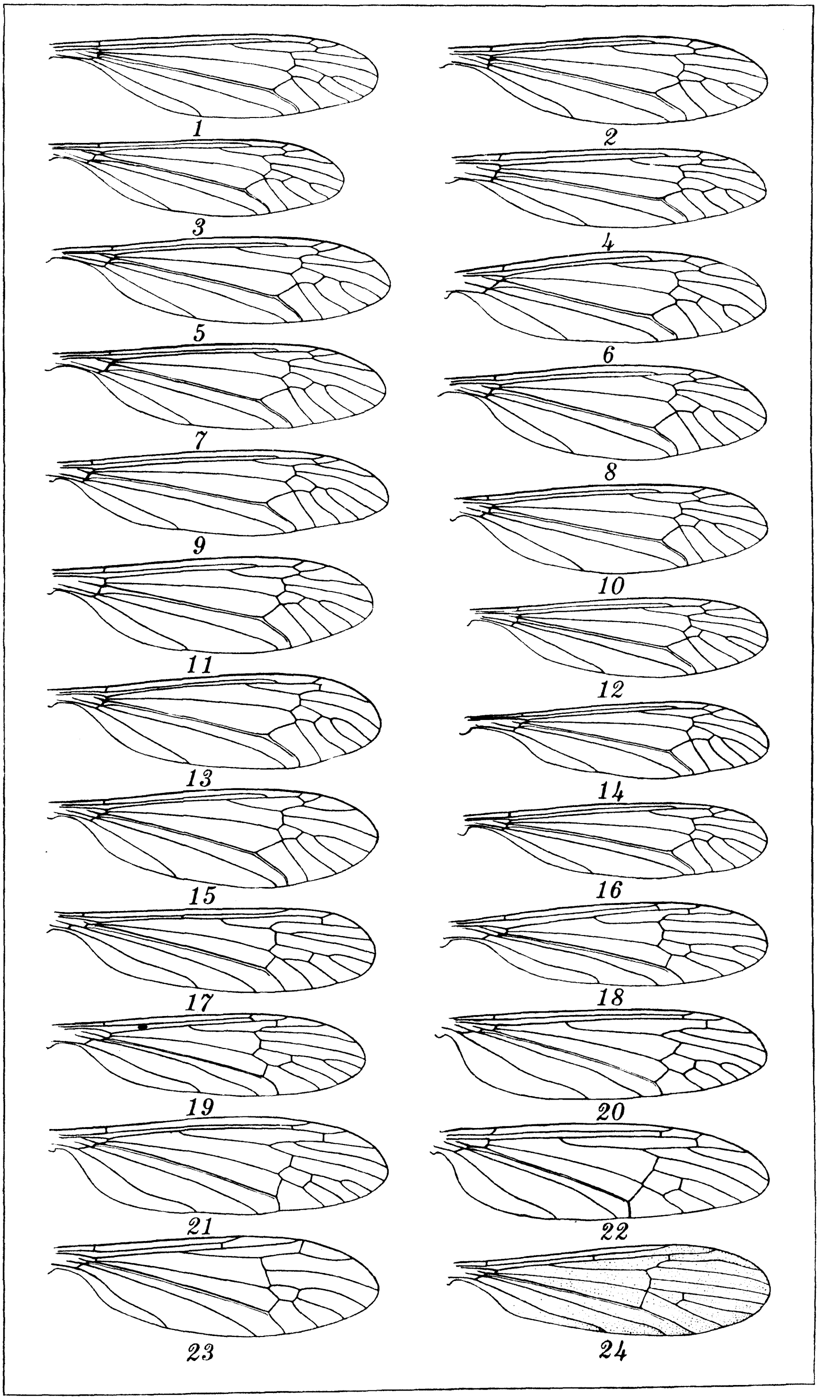
FIG. 25. *Tipula* (*Tipula*) *stackelbergi* sp. nov., male hypopygium, details.
26. *Tipula* (*Tipula*) *subsulphurea* sp. nov., male hypopygium, details.
27. *Tipula* (*Tipula*) *morigera* sp. nov., male hypopygium, details.
28. *Tipula* (*Tipula*) *parvincisa* sp. nov., male hypopygium, details.
29. *Tipula* (*Tipula*) *protrusa* sp. nov., male hypopygium, details.
30. *Tipula* (*Vestiplex*) *tumulta* sp. nov., male hypopygium, details.
31. *Tipula* (*Acutipula*) *omeiensis* sp. nov., male hypopygium, details.
32. *Tipula* (*Acutipula*) *vana* sp. nov., male hypopygium, details.

PLATE 3

FIG. 33. *Tipula (Acutipula) cockerelliana* Alexander, male hypopygium, details.
34. *Tipula (Acutipula) acanthophora* sp. nov., male hypopygium, details.
35. *Tipula (Lunatipula) validicornis* sp. nov., male hypopygium, lateral aspect.
36. *Tipula (Lunatipula) validicornis* sp. nov., male hypopygium, details.
37. *Tipula (Lunatipula) validicornis* sp. nov., ovipositor, details.
38. *Tipula (Lunatipula) pseudogyne* sp. nov., ovipositor, details.
39. *Tipula (Lunatipula) turanensis* sp. nov., male hypopygium, lateral aspect.
40. *Tipula (Lunatipula) turanensis* sp. nov., male hypopygium, details.
41. *Tipula (Lunatipula) turanensis* sp. nov., male hypopygium, details.

PLATE 4

FIG. 42. *Tipula mitophora* sp. nov., male hypopygium, lateral aspect.
43. *Tipula mitophora* sp. nov., male hypopygium, ninth tergite.
44. *Tipula apicispina* sp. nov., male hypopygium, details.
45. *Tipula mupinensis* sp. nov., male hypopygium, details.
46. *Tipula fortistyla* sp. nov., male hypopygium, details.
47. *Pedicia (Tricyphona) ussurica* sp. nov., male hypopygium.
48. *Limnophila (Limnophila) politostriata* sp. nov., male hypopygium.
49. *Hexatoma (Eriocera) ussuriensis* sp. nov., male hypopygium.
50. *Ormosia chankana* sp. nov., male hypopygium.



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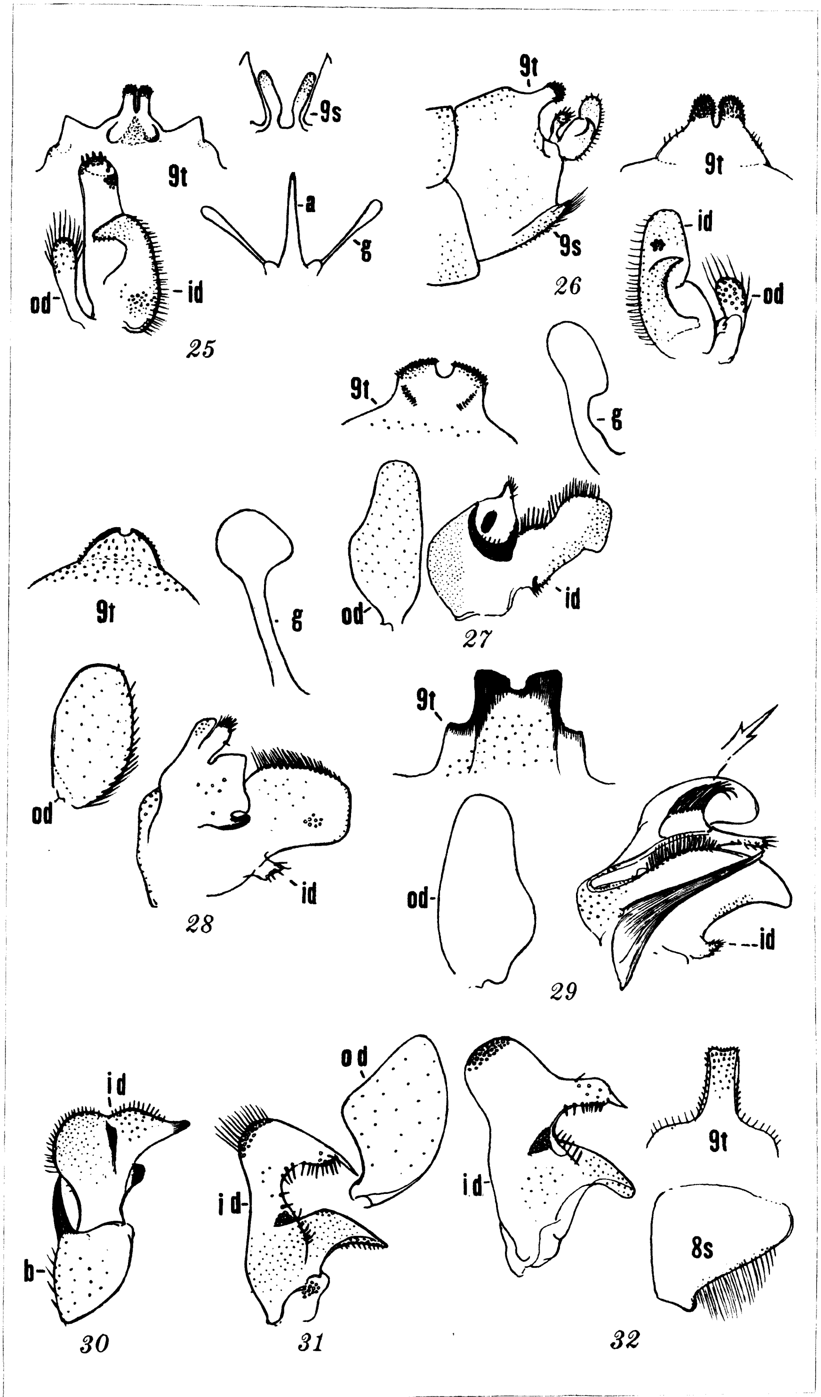
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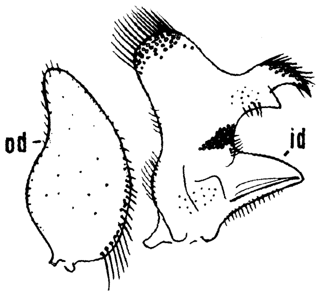

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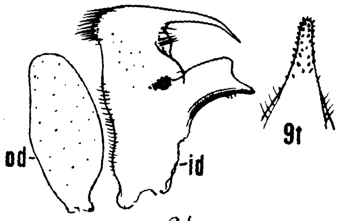

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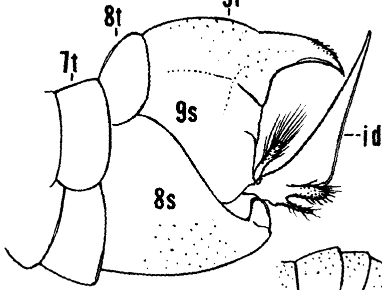

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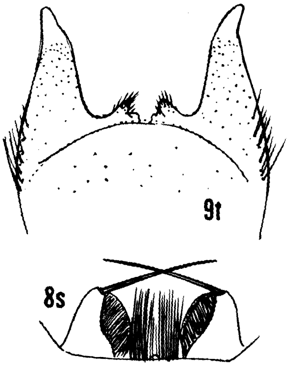

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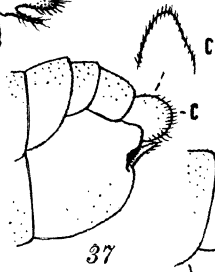

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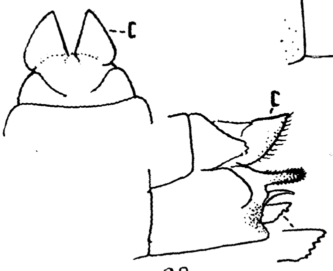

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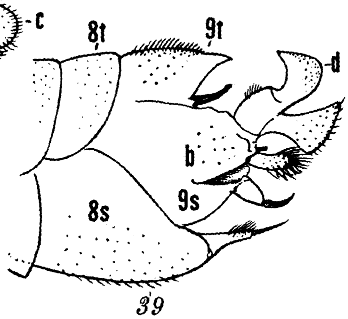

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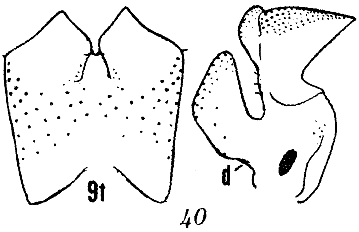

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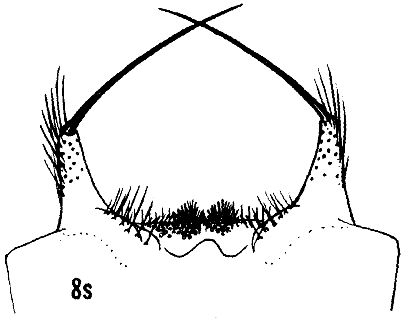

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PLATE 3.

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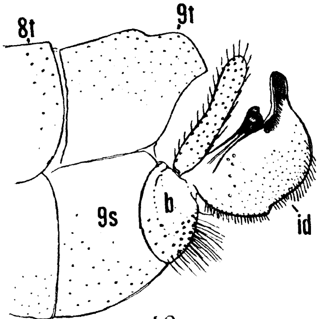

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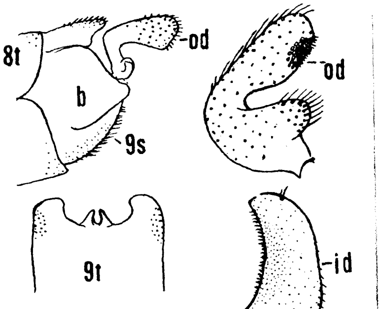

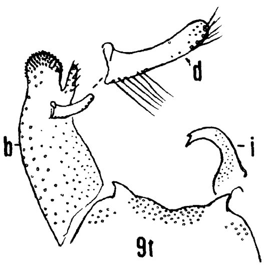

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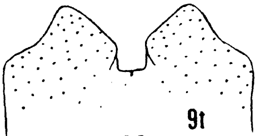

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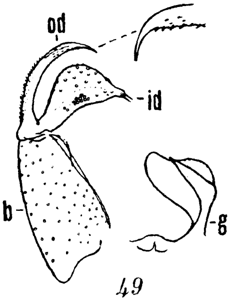

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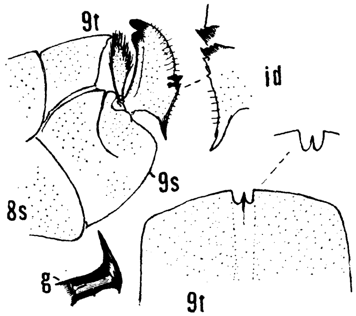

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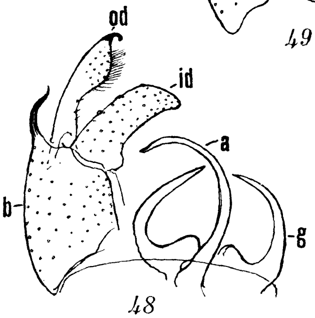

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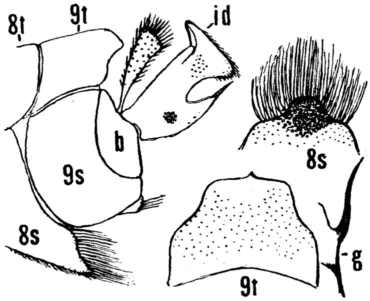

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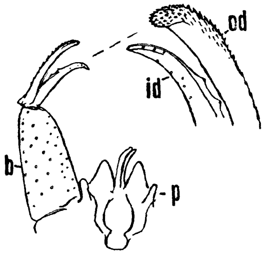

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PLATE 4.

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VOL. 52 DECEMBER, 1933 NO. 4

TUBERCULOSIS OF SWINE IN THE PHILIPPINE ISLANDS [1]

By TEODULO TOPACIO

*Of the Veterinary Research Division, Bureau of Animal Industry
Manila*

THREE PLATES

In his historical account of tuberculosis in the Philippine Islands presented before the First National Anti-Tuberculosis Congress in 1926 Calderon(1) stated that the disease was as old as the history of the Filipino people. Prior to 1902, when the American administration established the first Board of Health, no records were available of any organized effort to control or eradicate tuberculosis during the Spanish régime. Even this newly created Board of Health did not provide definite plans to combat the disease, because its major activities embraced health problems of a more general nature. It was only in 1908 that the City Council of Manila passed an ordinance prohibiting spitting in public places, vehicles, etc. If this was the situation with regard to human tuberculosis, it would seem reasonable to believe that the occurrence of the disease in swine was not even suspected. Indeed, among many early chronicles there was nothing to indicate that any organized system of examining meat animals for human consumption was promulgated by law. Consequently, no published work dealing with tuberculosis in local swine is available.

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[1] Bureau of Animal Industry Technical Bulletin 3. From the veterinary division, Bureau of Animal Industry, Manila. Received for publication April 4, 1933.

INCIDENCE

The establishment of a meat-inspection service at the Manila abattoir by the Bureau of Agriculture in 1907 brought to light the presence of what was thought to be tuberculosis in native swine. The entire carcass of any hog slaughtered at the abattoir was condemned as unfit for food when it showed apparent lesions of generalized tuberculosis, and parts were condemned when the lesions were local. In Table 1, it can be noted that during the year 1916 there were 157 whole carcasses and 507 parts condemned for tuberculosis from a total of 93,643 hogs slaughtered. The condition was the reverse in 1928, when of 122,717 slaughtered only 8 whole carcasses were condemned as against 13,538 parts. The fall in the number of whole carcasses condemned might be due, in a measure, to a more careful selection on the part of the wholesale hog dealers to meet the rigid meat-inspection regulations. From the standpoint of epizoölogy, the figures in the table do not represent the actual extent of the disease in the swine population of the country, as will be shown.

TABLE 1.—*Tuberculous carcasses and parts of hogs condemned at the Manila abattoir, 1907–1931.*

[Prepared by the animal statistics section, animal disease control division, Bureau of Animal Industry.]

Year.	Number slaughtered.	Tuberculous carcasses.	Tuberculous parts.	Year.	Number slaughtered.	Tuberculous carcasses.	Tuberculous parts.
1907	55,360	1	----------	1921	104,017	31	454
1908	58,119	----------	----------	1922	115,034	32	244
1909	60,789	----------	----------	1923	114,961	36	385
1910	63,043	----------	----------	1924	119,877	42	445
1911	65,593	8	----------	1925	118,763	29	253
1912	71,060	15	363	1926	116,731	21	269
1913	103,238	11	969	1927	117,063	14	4,707
1914	75,543	----------	326	[b] 1928	122,717	8	13,538
1915	84,736	10	175	1929	133,011	2	9,568
[a] 1916	93,643	157	507	1930	123,532	6	5,357
1917	107,626	76	1,370	1931	112,405	9	667
1918	106,145	8	641	Total----	2,465,425	542	40,555
1919	109,118	7	96				
1920	109,662	19	201				

[a] High condemnation of whole carcasses and comparatively few parts.
[b] Low condemnation of whole carcasses and high number of parts.

As a result of the heavy condemnation of parts of tuberculosis in 1928 there were numerous complaints from the wholesale dealers. In 1930, the agitation was such that a question arose as to whether or not the lesions found in the hogs were really due to tuberculosis infection. Verifying the presence of the tubercle bacilli in the lesions, isolating them in pure culture, and identifying the types involved, became the object of the present investigation. Examination of tubercle nodules from the lesions of condemned parts revealed acid-fast organisms. Tissue suspensions from such nodules injected into guinea pigs produced lesions of tuberculosis from which pure cultures of tubercle bacilli were obtained. Thus, the previous reports of tuberculosis at the Manila abattoir were definitely confirmed.

Tuberculin test.—In order to correlate the findings of tuberculosis in swine at the Manila abattoir with the actual prevalence of the disease in natural infection, the intradermal test was applied to fifty-three hogs in Navotas, Rizal, a town just outside Manila, and 35.8 per cent gave positive reactions to tuberculin. Six native pigs at the veterinary research laboratory purchased from Angat, Bulacan, for experimental purposes, were likewise tested, and 50 per cent reacted. When these reactors were autopsied, one showed lesions of generalized tuberculosis while the other two exhibited local lesions in the submaxillary glands. Pure cultures of tubercle bacilli were recovered, and when injected into guinea pigs and rabbits they proved to be uniformly pathogenic.

In view of the alarming incidence of tuberculosis in the human population of Navotas—90 per cent according to health reports—there seemed to be a direct relationship between the infection in man and in swine. This was supported by the observation that all the hogs that reacted to tuberculin were found among animals running at large and none among those kept in pens. The logical assumption was that the animals roaming about contracted the disease through mass exposure to infected human material scattered on the premises. The open privy system generally used in the rural districts offered a constant source of such infected material to which these scavengers had free access. The lack of a meat-inspection system in the municipalities made the existence of a vicious circle not only conceivable but probable.

TYPE OF TUBERCULOSIS IN SWINE

In the United States and other countries the type of tuberculosis affecting swine may be regarded as intimately associated with the dairy and poultry industries. Hull(13) estimates that 75 per cent of tuberculosis in the hogs slaughtered in Chicago in 1917 was due to the avian type, because the Western States, which furnished most of the hogs, also possessed a well-developed poultry industry with some poultry farms infected with avian tuberculosis. In the Eastern States, however, where the dairy industry was highly developed, the hogs suffered from the bovine type of organisms because many dairy herds were infected with bovine tuberculosis. Calmette(2) observed that the avian type predominated in hogs slaughtered at the abattoir of Buenos Aires, Argentine Republic. In the Philippines the dairy and poultry industries are in their infancy, yet tuberculosis is found in hogs coming from neighboring provinces and slaughtered in Manila. Under the circumstances suspicion logically turns to the human type of infection as the probable source.

Isolation.—Of the materials obtained at the abattoir from swine during the latter part of 1930 and the beginning of 1931, eleven isolations were successful. Due to intercurrent organisms, attempts to obtain pure cultures directly from the lesions, even by the use of various methods of chemical sterilization, failed in many instances. The different technic worked out by Corper and Uyei(4 to 8) for the isolation of tubercle bacilli gave equally varying results. This might be due to difference in the nature of the clinical materials, as these authors confined most of their work to human sputa and body fluids where tissue débris did not appear to be a disturbing factor. Subcutaneous and intraperitoneal injections of macerated nodules into small animals, however, gave rise to uncontaminated lesions of tuberculosis from which pure cultures could be obtained and grown on artificial media.

In this connection Magath and Feldman,(16) in an extensive review of the various cultural methods used in the diagnosis of tuberculosis of known or suspicious materials, concluded that the inoculation of guinea pigs remains the best method of proving the presence of *Mycobacterium tuberculosis* in a given specimen. They stated further that primary cultures in a pure state are more readily obtainable from the guinea-pig lesions than from the original materials. The writer, however, in the case of spleen tuberculosis of swine, was able to secure pure cultures from the infected organ by direct isolation.

Choice of culture media.—By experience, certain media were found to be particularly suitable for certain strains of tubercle bacilli. However, the solid media with plain egg as a basis are known to possess the general requirements, with or without glycerine. Corper and Uyei insist on using their own media, Petroff(2) considers his medium more suitable, Sweany and Evanoff(22) prefer their milk-cream-egg medium for isolating tuberculosis of bovine origin, Miraglia(17) prefers his medium for human strains, and Griffith,(11) the foremost English worker on tuberculosis, emphasizes the fact that the various modifications of egg media are not superior to plain egg as a stock medium for isolating tubercle bacilli from tissues. Feldman,(10) after a comparative study of various media, concluded that for primary isolation of the human type Miraglia's medium was best, and for the bovine type, the modified medium of Sweany and Evanoff. Herold(12) claims that in his medium colonies may appear as early as five days after direct inoculation with tuberculous human sputum. The report of Lowenstein(15) on his success in cultivating fourteen specimens of urinary sediment from human cases in his medium is interesting, because he claims to have failed to produce infection in three guinea pigs with three samples which were positive in cultures. I have had no experience with this medium. In my hands, Dorset's(9) and Sweany and Evanoff's media have proved satisfactory for obtaining primary cultures from septic materials (Plate 3).

TYPING TUBERCLE BACILLI

Those who have had experience with the work of differentiating the human, bovine, and avian types of tubercle bacilli realize that it is difficult if not impossible to rely upon any one method. Morphological differences as to the appearance of colonies, staining properties of the bacilli, size, shape, etc., are disconcerting. Indeed, under certain conditions of food environments the three types may resemble one another in these respects. Opinion is divided as to what particular method of differentiation is best. Park, Williams, and Krumwiede consider intravenous injection of rabbits a decisive test in differentiating the human and bovine strains. Cobbett(3) has prepared a chart of virulence test in rabbits, guinea pigs, rats, chickens, etc., in order to recognize the three types of tuberculosis. Griffith employs cultural methods on Loeffler's and the various glycerinated media together with virulence test in small animals. More recently Mishulow(18) believes that she can distinguish between the three types of tubercle bacilli by a careful study of colony photographs on plates of Bordet-Gengou and Lowenstein media. According to Toda,(23) of Japan, the skin reaction following intracutaneous injection in rabbits differentiates the human and bovine strains. In the present study, I have assembled the various methods into four groups; namely, (*a*) typing by cultural method, (*b*) typing by susceptibility tests, (*c*) typing by the intradermal and intravenous injection in rabbits, and (*d*) typing by the character of the morbid changes.

FIRST SERIES

1. *Typing by cultural methods.*—Four strains of the series—TB. 10, TB. 15, TB. 18, and TB. 20—were selected for the first part of this study. The following media were used: Plain agar pH 7.4, glycerine agar pH 7.6, Petroff's medium according to Standard Methods (Wadsworth), ox-bile broth (pure fresh bile) sterilized fractionally, and chicken-bile broth.

Each strain was planted on these media in duplicate sets; one set was incubated at 37° C. and the other at 40° to 42° C. for four weeks before the results were read. Cultures incubated at 37° C. showed successful growth on the solid media but none on the ox- and chicken-bile tubes where the inoculum promptly sank to the bottom of the liquid. This behavior would indicate the human type of tubercle bacilli. The duplicate cultures grown at 40° to 42° C. exhibited doubtful or no growth whatever. This and the fact that there was no growth on chicken bile would indicate that no avian tubercle bacilli were present in the series. No less than six tubes of each medium were used for each strain. Repetition yielded essentially the same result, which is summarized in Table 2.

TABLE 2.—*Cultures incubated at different temperatures.*

AT 37° C. FOR FOUR WEEKS.

TB. strain.	Plain agar.	Glycerine agar.	Petroff's medium.	Ox bile.	Chicken bile.
No. 12	Scanty growth	Heavy growth	Growth	Fat pellicle	Negative.
No. 15	do	do	do	do	Do.
No. 18	Very thin growth	do	Good film	do	Do.
No. 20	Fair	do	Good growth	do	Do.

AT 40° TO 42° C. FOR TWO WEEKS; AT ROOM TEMPERATURE FOR FOUR WEEKS.

No. 12	Growth doubtful	—	—	Fat scum?	Negative.
No. 15	do	—	Doubtful	Fat scum	Do.
No. 18	do	Doubtful	do	Fat scum and sediment.	Do.
No. 20	Few colonies?	do	do	Fat scum	Do.

2. *Typing by susceptibility tests and character of morbid changes.*—Cultures of the four strains were planted on glycerine agar or Petroff's medium and grown for at least six weeks. Depending on the density of growth, one or two slant cultures were emulsified into a paste in glycerine broth in a sterile mortar and then diluted to a suspension equivalent to a standard containing about 0.01 mg per cubic centimeter. Separate sterile syringes and containers were used for each strain. For each strain three rabbits and two guinea pigs were injected both intradermally and intraperitoneally. One rabbit in each test received 0.2 to 0.3 cc intradermally, which according to Toda produces a persistent cutaneous ulcer in a true bovine strain. For controls, three rabbits were injected with a known bovine culture and one guinea pig with a known human strain.

At the end of ten weeks the animals that survived were killed and autopsied. In animals without visible lesions but showing suspicious signs of the disease, the organs were sectioned, stained, and examined for tuberculous lesions. Stained smears from suspected organs were also examined for tubercle bacilli. As a presumptive test of infection, all surviving animals were given the intradermal tuberculin test before being killed. Readings were recorded on a chart according to the intensity of the reaction. There being no history of spontaneous tuberculosis among the animals used, a preinjection tuberculin test was considered unnecessary. Table 3 represents the average result obtained from repeated tests with each strain.

The high virulence to guinea pigs, the benign local effects on rabbits, and the failure to infect chickens strongly indicated that these four strains were human type of tubercle bacilli. Moreover, the skin reaction of Toda in rabbits was uniformly negative with each strain although a slight tuberculin reaction was noted.

SECOND SERIES

1. *Typing by cultural methods.*—For the study of cultural and morphological characters of the seven strains in this series, six to twelve tubes of each medium were used for each strain. In this instance, however, the selective media of Miraglia, Loeffler, Dorset, and Evanoff were employed. Special reliance was placed on the morphology and type of growth on Loeffler's medium and the group of glycerine media as recommended by Stanley Griffith in differentiating the three types of tubercle bacilli. Complete observations are recorded in Table 4.

TABLE 3.—*Typing by susceptibility test in rabbits, guinea pigs, and chickens (first series).*

TB. strain.	Species.	Route of injection.	Tuberculin reaction.	Killed or died.	Post-mortem lesions.
No. 12	Rabbit 1	Intradermal	++	Killed 75 to 81 days after injection	Localized TB.
No. 12	Rabbit 2	Intraperitoneal	+++	do.	Do.
No. 12	Rabbit 3	do.	++	do.	Do.
No. 12	Guinea pig 1	do.	+	do.	Generalized TB.
No. 12	Guinea pig 2	do.	0	Died 15 days after injection	Lymph gland TB.
No. 12	Chicken 1	do.	—	Killed 75 to 81 days after injection	Negative TB.
No. 15	Rabbit 4	Intradermal	++	do.	Localized TB.
No. 15	Rabbit 5	Intraperitoneal	++++	do.	Do.
No. 15	Rabbit 6	do.	++++	do.	Do.
No. 15	Guinea pig 3	do.	0	Died 28 days; after injection	Generalized TB.
No. 15	Guinea pig 4	do.	0	Died 33 days after injection	Do.
No. 15	Chicken 2	do.	—	Killed 75 to 81 days after injection	Negative TB.
No. 18	Rabbit 7	Intradermal	—	do.	No gross lesions.
No. 18	Rabbit 8	Intraperitoneal	+++	do.	Localized TB.
No. 18	Rabbit 9	do.	—	Died 63 days after injection	Hydropericardium ascites.
No. 18	Guinea pig 5	do.	++++	Killed 75 to 81 days after injection	Generalized TB.
No. 18	Guinea pig 6	do.	++++	do.	Do.
No. 18	Chicken 3	do.	++	do.	Negative TB.; mummified ovaries.
No. 20	Rabbit 10	Intradermal	—	do.	Localized TB.
No. 20	Rabbit 11	Intraperitoneal	++	do.	Do.
No. 20	Rabbit 12	do.	+	do.	Do.
No. 20	Guinea pig 7	do.	0	Died 52 days after injection	Cachexia, generalized TB.
No. 20	Guinea pig 8	do.	0	Died 71 days after injection	Localized TB.
No. 20	Chicken 4	do.	—	Killed 75 to 81 days after injection	Negative TB.
Controls:					
Bovine 22	Rabbit 13	do.	0	Died 82 days after injection	Generalized TB.
Bovine 22	Rabbit 14	do.	0	Died 65 days after injection	Do.
Bovine 22	Rabbit 15	Intradermal	0	Died 102 days after injection	Generalized TB.; persistent ulcers.
Human (M)	Guinea pig 9	Intraperitoneal	0	Died 56 days after injection	Generalized TB.
Avian (B. S.)	Chicken 5	do.	+++	Killed 75 to 81 days after injection	Do.

TABLE 4.—*Cultures on selective solid media incubated at 37° C. from one to two months (second series).*

Strain.	Miraglia's medium.	Loeffler's coagulated serum.	Dorset's medium.	Evanoff's medium.
No. 12	Luxuriant, yellow, spreading growth.	Fair growth, dull yellow, granular.	Fair and smooth.	Fair growth, dull in color.
No. 15	Very luxuriant, almost orange color; individual colonies raised.	Thin growth, yellowish, warty.	Very fine colonies, yellowish.	Dull white, surface rough, colonies raised.
No. 19	Luxuriant growth, yellowish, granular.	Spreading colonies, granular, uniform yellow.	Good growth, smooth surface, spreading.	Dull white, smooth colonies, fine and uniform.
No. 20	Very luxuriant, almost orange, colonies rough.	Slight, very fine growth, colonies isolated, yellowish, granular.	Rough, isolated colonies, yellowish.	Dull white colonies, isolated and rough.
No. 21	Luxuriant growth, almost orange color, colonies rough.	Thin growth, yellow, warty.	Colonies yellowish, rough, and isolated.	Dull white, isolated colonies.
No. 26	Luxuriant, dark yellow, rough and spreading.	Good growth, colonies warty and yellowish.	Scanty growth, fine.	Fair growth.
No. 28	Very luxuriant, warty, isolated colonies, almost orange.	Fair growth, yellow, granular.	Good growth, dark yellow, colonies adherent.	Rough, isolated, dull colonies.
No. 29	Fair growth, colonies rough and raised, dull yellow.	Good growth, yellow, granular.	Slight growth, colonies rough, yellowish.	Dull white, rough colonies.
No. 30	Luxuriant growth, colonies rough, isolated, warty, dull yellow.	Fair growth, warty, yellow.	Rough, isolated, dull colonies.	Dull white, raised colonies.
Control, human (M).	Luxuriant, rough growth, almost orange color.	Fair growth, yellow, granular.	Slight growth, isolated, rough, colonies.	Dull white, slow growth.

It will be observed that growth on the glycerinated medium of Miraglia was luxuriant for all the strains, while on the egg medium of Dorset and the cream medium of Evanoff the growths were either scanty or isolated. The yellow coloration on Loeffler's medium was observed in all strains and is claimed by Griffith as characteristic of human tubercle bacilli. It is interesting to note that in the media here employed, growth was evident after ten to fifteen days of incubation and at the end of one

TABLE 5.—*Typing by susceptibility tests (second series).*

Strain.	Species.	Route of injection.	Tuberculin reaction.	Killed or died.	Post-mortem lesions.
No. 10	Rabbit 10	Intradermal	+	Killed 66 days after inoculation	Localized TB.
No. 10	Rabbit 17	Intraperitoneal	+	Died 30 days after inoculation	Do.
No. 10	Rabbit 18	do	+	Killed 66 days after inoculation	Do.
No. 10	Guinea pig 10	do	+++	Died 58 days after inoculation	Generalized TB.
No. 10	Guinea pig 11	do		Died 27 days after inoculation	Do.
No. 10	Chicken 6	do		Killed 66 days after inoculation	Negative.
No. 19	Rabbit 19	Intradermal	++	do	Localized TB.
No. 19	Rabbit 20	Intraperitoneal	+++	do	Do.
No. 19	Rabbit 21	do	±	do	Do.
No. 19	Guinea pig 12	do		Died 24 days after inoculation	Do.
No. 19	Guinea pig 13	do		Died 36 days after inoculation	Generalized TB.
No. 19	Chicken 7	do		Killed 66 days after inoculation	Negative.
No. 21	Rabbit 22	Intradermal		Died 45 days after inoculation	Localized TB. skin.
No. 21	Rabbit 23	Intraperitoneal	+	Killed 46 days after inoculation	Localized TB.
No. 21	Rabbit 24	do	—	Killed 66 days after inoculation	Do.
No. 21	Guinea pig 14	do	++	do	Do.
No. 21	Guinea pig 15	do	+++	do	Generalized TB.
No. 21	Chicken 8	do		Died 33 days after inoculation	Negative.
No. 26	Rabbit 25	Intraperitoneal	([a])	Died 65 days after inoculation	Localized TB.
No. 26	Rabbit 26	do	([a])	Died 60 days after inoculation	Generalized TB.
No. 26	Guinea pig 16	do	([a])	Died 36 days after inoculation	Do.
No. 26	Guinea pig 17	do	([a])	Died 43 days after inoculation	Do.
No. 26	Chicken 9	do		Died 15 days after inoculation	Negative, tumor of liver.
No. 28	Rabbit 27	Intraperitoneal	([a])	Died 91 days after inoculation	Localized TB.
No. 28	Rabbit 28	do	([a])	Died 78 days after inoculation	Do.
No. 28	Guinea pig 18	do	([a])	Died 65 days after inoculation	Generalized TB.
No. 28	Guinea pig 19	do	([a])	Died 68 days after inoculation	Do.
No. 28	Chicken 10	do		Died 3 days after inoculation	Negative, peritonitis.

No. 29	Rabbit 29	Intraperitoneal	(a)	Died 85 days after inoculation	Localized TB.
No. 29	Rabbit 30	do		Died 69 days after inoculation	Do.
No. 29	Guinea pig 20	do	(a)	Died 65 days after inoculation	Generalized TB.
No. 29	Guinea pig 21	do	(a)	Died 72 days after inoculation	Do.
No. 29	Chicken 11	do	(a)	Killed 60 days after inoculation	Negative.
No. 30	Rabbit 31	Intraperitoneal	(a)	Died 65 days after inoculation	Localized TB.
No. 30	Rabbit 32	do	(a)	Died 85 days after inoculation	Generalized TB.
No. 30	Guinea pig 22	do	(a)	Died 67 days after inoculation	Do.
No. 30	Guinea pig 23	do	(a)	Died 59 days after inoculation	Localized TB.
No. 30	Chicken 12	do	(a)	Killed 63 days after inoculation	Negative.
Controls:					
Human (M)	Rabbit 33	Intradermal	+++	Killed 66 days after inoculation	Localized TB.
Human (M)	Rabbit 34	Intraperitoneal	+++	do	Do.
Human (M)	Rabbit 35	do	(a)	Died 47 days after inoculation	Do.
Human (M)	Guinea pig 24	do	(a)	Died 36 days after inoculation	Generalized TB.
Human (M)	Guinea pig 25	do	(a)	Died 35 days after inoculation	Do.
Bovine 22	Rabbit 36	Intradermal	(a)	Died 96 days after inoculation	Generalized TB.
Bovine 22	Rabbit 37	Intraperitoneal	(a)	Died 63 days after inoculation	Do.
Bovine 22	Rabbit 38	do	(a)	Died 47 days after inoculation	Do.
Bovine 22	Guinea pig 26	do	(a)	Died 45 days after inoculation	Do.
Bovine 22	Guinea pig 27	do	(a)	Died 46 days after inoculation	Do.

[a] No tuberculin test given.

month most of the cultures on Miraglia's and Loeffler's media were in a luxuriant condition. There was pronounced luxuriance, particularly on Miraglia's medium claimed to be selective for the human strain of tuberculosis. The rough, warty, dry nature of the colonies was likewise regularly observed in this medium. The behavior of these seven strains according to the above cultural and morphological observations would indicate that they were of human origin.

2. *Typing by susceptibility tests.*—In conducting tests with the seven strains in this series, a broth suspension of each strain was prepared separately from a six week's culture on Dorset's medium. The concentration was such that each cubic centimeter contained about 0.01 mg of culture. The animals assigned to each strain were injected as follows: One rabbit received 0.2 to 0.3 cc of suspension intradermally; two rabbits were given 1 cc each intraperitoneally; two guinea pigs and one chicken each were injected with 1 cc intraperitoneally. As controls, a suspension of a culture of known human strain and one of a known bovine strain were injected into two respective groups of animals. Those test animals that did not succumb too soon were each inoculated with 0.1 to 0.3 cc of tuberculin intradermally. The reactions in two readings were recorded before the animals were killed. Meticulous care was exercised during inoculations to avoid intercontamination of the various strains being tested. In testing strains 26, 28, 29, and 30 no intradermal injections were given because the animals were allowed to run the entire course of the disease until death. Detailed observations are recorded in Table 5.

As will be noted in the record of results, all seven strains were uniformly fatal to guinea pigs. The rabbits, on the other hand, presented localized lesions only, while the guinea pigs developed a generalized condition. All the chickens remained healthy, and when they were killed no lesions were found. The pathogenic behavior of these seven strains was indicative of the human type of tubercle bacilli and agreed quite well with the action of the known human strain used as a control. Furthermore, no persistent cutaneous ulcers of Toda were observed in any of the rabbits that received the intradermal injection.

3. *Typing by the character of morbid changes.*—It is realized that differentiation by this means is not absolutely specific, but if the collective features of the complete autopsy lesions are considered, with some experience, such differentiation is possible. For example, no matter what the route of administration, a

suitable dose of a pathogenic bovine strain attacks the lungs of the rabbit more frequently and extensively, causing a confluent pulmonary tuberculosis, which results in generalized infection and death. Such a picture is obtained particularly when the infection is permitted to run its entire course until the death of the animal. In the case of an infection with the human strain of tubercle bacilli, the rabbit suffers from a localized type of lesion, and although the lungs become involved, the nodules are few and discrete. The extension of the lesions to other organs does not seem to alter the localized picture. With the seven strains here tested, the morbid changes produced agreed with those brought forth by the known human strain. Likewise, the persistent skin ulcer of Toda proved to be quite specific for the bovine type of bacilli as it affects the rabbit skin, but no such reaction was observed in any of the strains tested (Plates 1 and 2).

COMBINED FIRST AND SECOND SERIES

1. *Typing by intradermal and intravenous injections in rabbits.*—Like the intravenous injection, the intradermal inoculation is for the purpose of differentiating the bovine from the human strains. This method was incorporated in the previous virulence tests (Tables 3 and 5) and the results included therewith. A combined test of the first and second groups was made by the intravenous method and the result summarized in Table 6.

TABLE 6.—*Typing by intravenous injections of rabbits (first and second series).*

Strain.	Species.	Dose of culture.	Killed or died.	Post-mortem lesions.
		cc.		
No. 10	One female rabbit.	1	Killed 43 days after inoculation.	Localized pulmonary TB.
No. 12	do	1	Killed 55 days after inoculation.	Pulmonary TB.
No. 15	do	1	do	Localized pulmonary TB.
No. 18	do	1	Died 41 days after inoculation.	Negative for visible lesions.
No. 19	do	1	Died 28 days after inoculation.	Localized pulmonary TB.
No. 20	do	1	Killed 55 days after inoculation.	Do.
No. 21	do	1	Killed 43 days after inoculation.	Do.
Human (M)	do	1	Killed 55 days after inoculation.	Do.

The most notable feature of typing by the intravenous injection in rabbits was the uniform type of local tuberculosis that developed in the lungs. With a true bovine strain (Park, Williams, Krumwiede, and Griffith) the rabbits die of generalized infection involving the spleen, liver, and kidneys. Such lesions were not observed in any of the rabbits used in the above list.

Intravenous injections of 1 cc of culture suspension (0.01 mg) into rabbits produced only mild tuberculosis of the lungs, which is typical of the effects of injecting the human strain. In connection with the successful infection of tuberculosis in highly susceptible animals, Griffith states that the dosage and the method of inoculation is immaterial, provided that the organisms are virulent. According to the careful experiments of B. Lange (1928) (4) one virulent tubercle bacillus is sufficient to produce infection by inhalation.

DISCUSSION

The meat inspection system established in 1907 under American administration made possible the recognition of a disease condition in swine that proved to be a true tuberculosis infection. Although the system of condemnation was based upon the presence of visible lesions alone and was by no means perfect, such procedure served to safeguard the pork-consuming public. From a practical standpoint, such a method of eliminating actually diseased meat from the public markets served the purpose quite efficiently. It is to be noted, however, that the confirmatory finding of true tuberculosis organisms in such condemned parts did not materialize until quite recently, as a result of the present study.

Tuberculin test on fifty-three hogs at Navotas revealed 35.8 per cent infection while in six hogs of the veterinary research laboratory three, or 50 per cent, reacted. Autopsy of these three animals revealed generalized tuberculosis in one and local tuberculosis of the submaxillary glands in the other two. Tubercle bacilli were present in the smears from lesions of all three animals. These results leave no room for doubt as to actual existence of true tuberculosis infection in native swine.

While the figures of incidence shown by the tuberculin test in Navotas and Angat were very high and apparently did not correspond to the percentage of condemnation on the killing floor at the Manila abattoir, it should be noted that the conditions under which the two results were obtained were totally different. The reactors from the tuberculin test included both the tuberculous animals with no visible lesions at autopsy and those that showed visible lesions of a local or generalized character. On the killing floor of the abattoir, on the other hand, diagnosis was based entirely upon the presence of visible gross lesions on the carcass; consequently, occult foci of a microscopic nature in the tissues and minor recesses of the body were beyond the range of such ocular inspection.

Direct isolation of pure tubercle bacilli from tuberculous lesions, whether it be from human beings, cattle, or other animals, has always been a common difficulty among laboratory workers. My experience in this work on pig lesions confirmed this, as in many cases chemical methods were utterly unsuccessful in ridding the infected material of intercurrent organisms. Passage of the tuberculous materials through guinea pigs or rabbits and subsequent recovery of the organisms from the infected organs for cultivation, proved to be the most reliable means of securing uncontaminated cultures of tubercle bacilli. This is supported by the recent extensive review of Magath and Feldman on the subject. One exception, however, was in spleen tuberculosis, where direct isolation could be made with ease, as the tubercle nodules were not contaminated with other microörganisms.

In attempting to classify or type the kind of tuberculosis organisms in the four strains of the first series, the writer was aware of the difficulties involved in such an undertaking. Morphological differences between the human, bovine, or avian types of organisms are so full of discrepancies that any criterion on this basis alone is not conclusive. Cultural behavior in various differential media under different incubation temperatures offered a better method. With this, the results obtained were rather decisive. Among four strains of the first series incubated at 37° C., good growths were secured on glycerine agar and Petroff's inspissated egg, while the result in bile broth was not entirely satisfactory. No growth was seen in chicken-bile media. The growth tendency in these media suggested the behavior of the human type of organisms. Likewise, the absence of growth in the same media incubated between 40° and 42° C. apparently ruled out the presence of the avian type in the series.

The result of the differential test by animal susceptibility conducted with such strains was indicative of the human type. In nearly all cases the guinea pigs either succumbed to the injection or when killed revealed extensive tuberculosis, while the rabbits suffered only localized lesions, regardless of the route of inoculation. The persistent skin ulcers of Toda were not observed in rabbits receiving intradermal injection, but this reaction was readily demonstrated in the control intradermal rabbit that received the known bovine strain (Plate 2). Moreover, this rabbit died of generalized tuberculosis of the lungs, spleen, liver, and kidneys. Ravenel(21) produced a similar type of infection by subcutaneous injection. The rabbits that received intradermal injections of the control human strain did not die and the skin lesion healed completely (Plate 1). All the chickens used survived, and when killed, were negative for tuberculosis. The known control bovine strain killed all the rabbits in 36, 45, and 60 days respectively, with generalized tuberculosis. The known human type killed the guinea pig in 34 days with generalized tuberculosis. Similarly the control avian strain produced generalized tuberculosis in the chicken injected. Such sweeping evidence from the result of this susceptibility test would fortify the conclusion that these four strains were of human origin. Quite recently Mishulow stated that she could differentiate between the human, avian, and bovine types by colony growths on Bordet-Gengou and Lowenstein plates. This work needs further confirmation.

Observations on seven other strains of a second series on selective solid media as well as the virulence tests conducted on rabbits, guinea pigs, and chickens, generally speaking, resembled those of the other four in the first series morphologically, culturally, and in their essential pathogenic action. Likewise, the character of the lesions produced in rabbits and guinea pigs were similar to those brought about by the injection of a known culture of human tubercle bacilli. This would indicate that the strains of the second series were also of human origin.

The failure to isolate avian or bovine types among the eleven strains in the present study is no criterion that such types do not actually exist in native swine. It is more than likely that a study of hogs kept in a known tuberculous dairy herd in the City of Manila or elsewhere would reveal an infection with the bovine type. Similarly, the avian type of tuberculosis would likely be present among hogs of a known tuberculous poultry farm. Reference has already been made to infection in hogs with the bovine and avian types in large tuberculous dairy and poultry farms in the United States and other countries where these industries are highly developed.

It appears that in the light of the facts thus far advanced, human tuberculosis infection in swine creates a vicious circle and constitutes a detriment to the hog industry and a potential menace to public health. Evidence of an existing relationship between the alarming incidence of tuberculosis in the human population of Navotas, Rizal, and the great prevalence of the disease in swine was brought forth by the result of the tuberculin test in the hogs, a number of which were confirmed by autopsy. Proper disposal of infected human material would go a long way to prevent the spread of the disease among hogs, and in the end contribute indirectly to a successful campaign of tuberculosis eradication in human beings. An efficient meat inspection system in the principal municipalities of the Archipelago is imperative in order to insure clean and wholesome table pork.

CONCLUSION

1. Tuberculosis infection in Philippine swine is hereby definitely established.
2. *Mycobacterium tuberculosis* organisms lightly pathogenic to rabbits but highly so to guinea pigs were isolated from lesions of infected hogs and cultured on artificial media.
3. The result of typing eleven strains herein presented on the basis of their morphology, cultural behavior, and pathogenicity to the small animals employed, strongly indicates that they were of human origin. It does not follow, however, that the avian or bovine strains might not exist in native hogs, for no study was made of animals in known infected dairy or poultry farms.
4. Sufficient evidence was adduced that hogs contract the disease through mass exposure to infected human material because of the open privy system in vogue in the rural districts. This is supported by the high incidence of tuberculosis in hogs running at large.
5. Human tuberculosis in swine is not only a detriment to the hog industry of the country but is also a potential menace to public health in relation to the ultimate eradication of "white plague" in human beings.
6. Proper disposal of infected human material on the one hand and the establishment of an efficient municipal meat inspection system on the other would prevent the spread of infection in hogs and would insure to the public wholesome table pork.

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ILLUSTRATIONS

PLATE 1

FIG. 1. Skin reaction in rabbit, *a*, after injection of human tubercle bacilli.

2. Lesion magnified about three times; *p*, a shallow ulcer at the point of inoculation which eventually healed.

3. Pulmonary tuberculosis after injection of human tubercle bacilli; *t*, discrete nodules.

PLATE 2

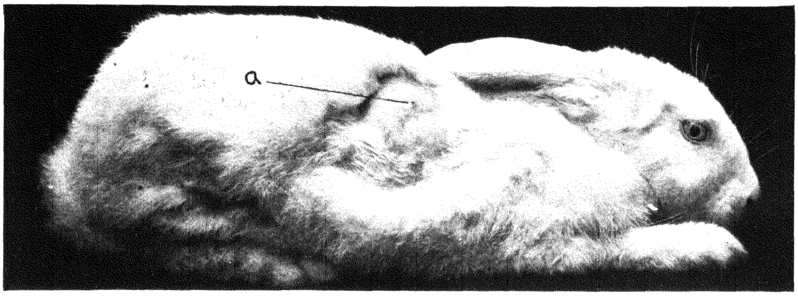
FIG. 1. Skin reaction, *a*, in rabbit after injection of bovine tubercle bacilli.

2. Persistent skin ulcers of Toda, *u*, natural size of fig. 1, *a*.

3. Pulmonary tuberculosis after injection of bovine tubercle bacilli; *t*, confluent tuberculous nodules, involving the two lungs.

PLATE 3

Young primary cultures of tubercle bacilli isolated from swine lesions; Dorset medium.



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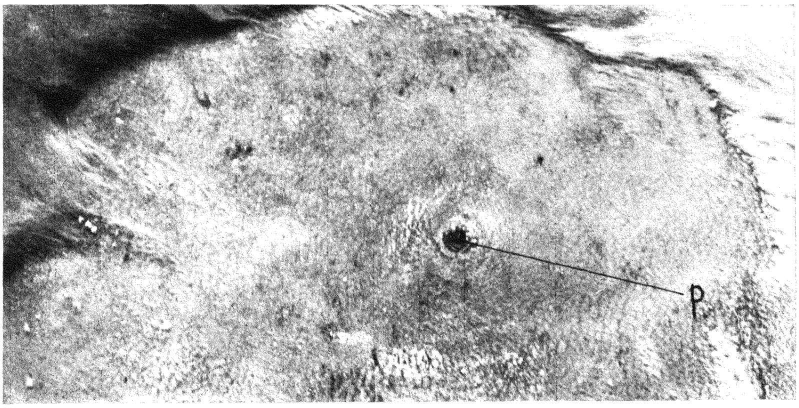

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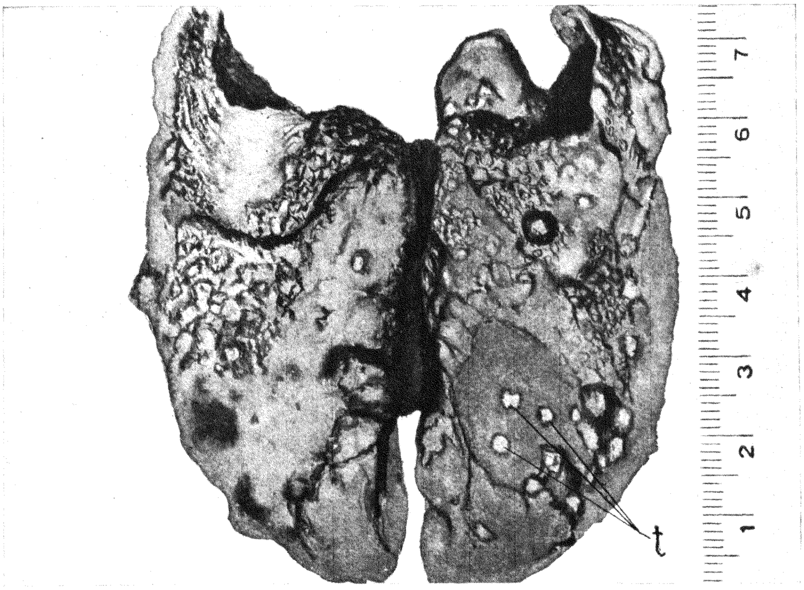

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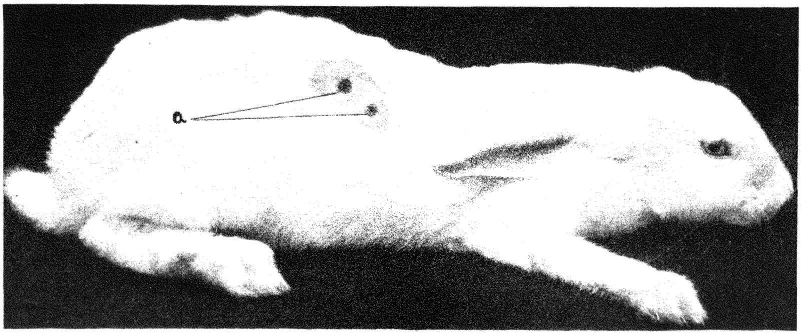
PLATE 1.



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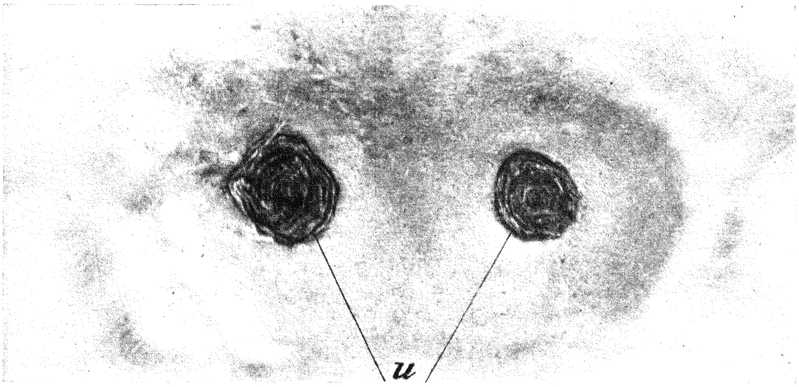

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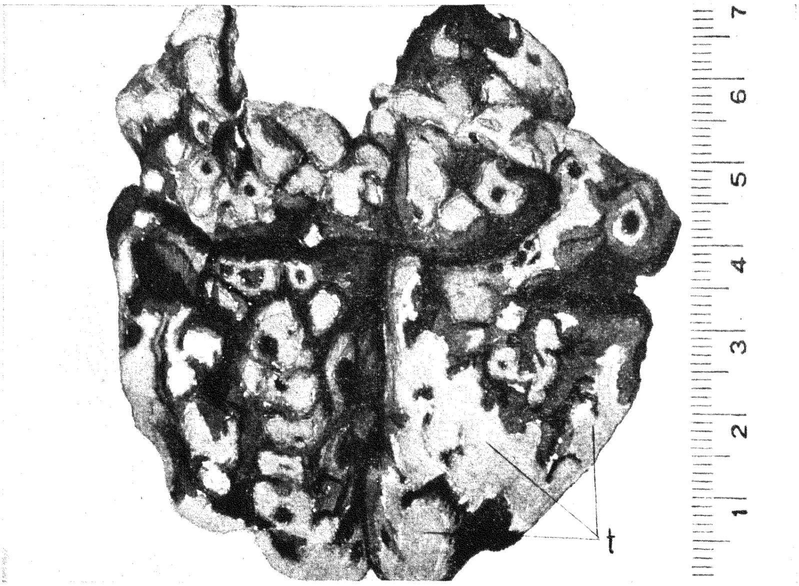

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PLATE 2.

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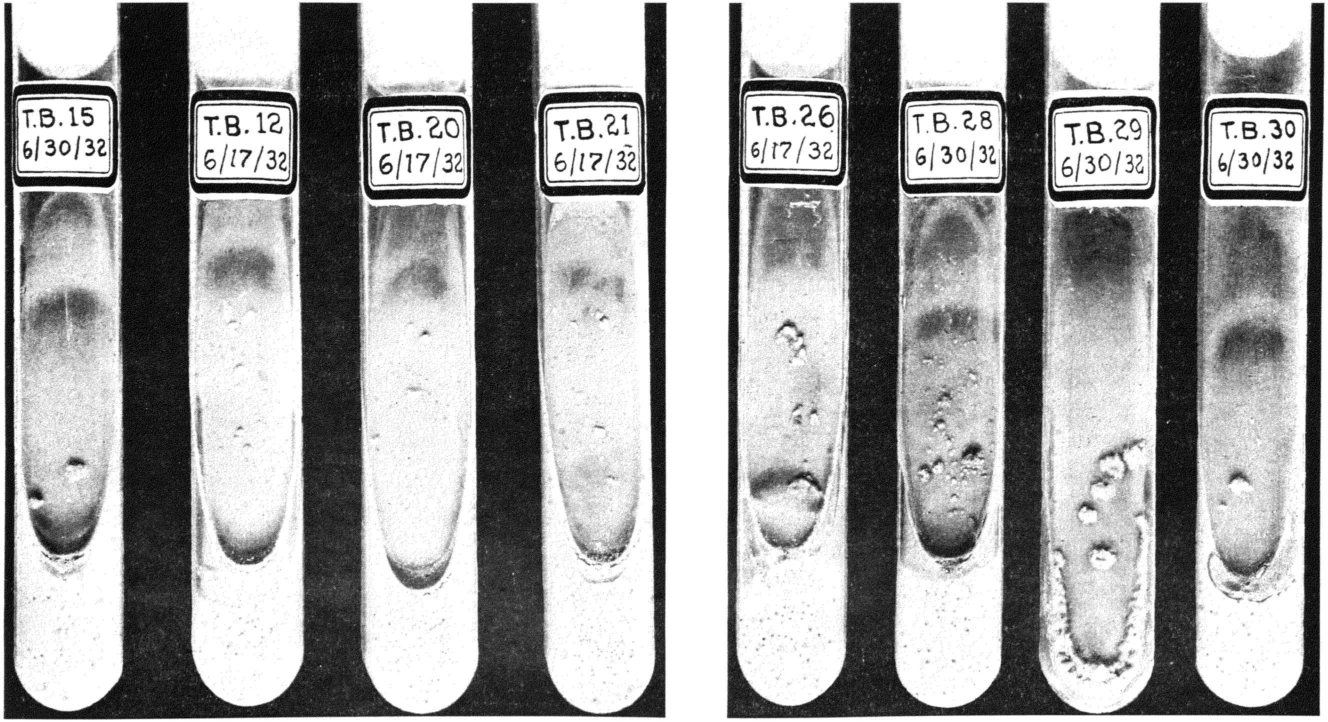

PLATE 3.

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DEVELOPMENT OF THE ANCHOR AND ANCHOR-PLATE TYPES OF SPICULES OF THE SYNAPTID POLYPLECTANA KEFERSTEINII (SELENKA) AND ALLIED SPECIES

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ONE PLATE AND TWO TEXT FIGURES

INTRODUCTION

The growth and development of the calcareous spicules in holothurians is not a new subject of study. However, the writer presents here a description of the spicule formation in *Polyplectana kefersteinii* (Selenka) and other species. In all known holothurians of the order Actinopoda or Pedata the various kinds of spicules, the tables and buttons for example, are derived from an X-shaped fundament (Gerould, 1896). In synaptids, order Paractinopoda or Apoda, the anchor and anchor plate are formed from a simple rod-shaped fundament derived from specialized mesenchymal cells in the connective-tissue layer (Clark, 1907). These calcareous spicules are almost entirely, if not entirely, composed of pure carbonate of lime.

GENERAL DESCRIPTION OF THE ANCHOR AND ANCHOR-PLATE TYPES OF SPICULES

The anchor and the anchor plate, which are usually symmetrical, lie one over the other in the superficial layer of the body wall. The anchor consists of three parts; namely, the posterior stock or handle which is usually expanded; the shaft, a slender rod constituting the body of the anchor and lying with the concave side of the plate; and the anterior arms or appendages, usually meeting at the vertex. The arms are frequently serrated on the outer sides, and when smooth, there are usually several small knobs at the vertex of the anchor. The stock may be finely spinous or branched. In a few rare species the anchor bears arms at both anterior and posterior ends of the shaft. Not infrequently, the anchors are asymmetrical, one arm being larger than the other. Occasionally there is a third arm.

The anchor plate is more or less concave on the outer side. The posterior end is smaller, with several small holes and, frequently, with an outwardly curved bow which arches the concavity. In the majority of cases the anchor plates are symmetrical, with six or seven serrated or toothed rings. In a few rare species the plates are asymmetrical with numerous small perforations. The anchor plates vary from 0.1 to 1 mm in length. The width varies from one-half to almost equal the length. A plate is always shorter than the anchor that accompanies it.

METHODS OF STUDY

The study of the spicules of *Polyplectana kefersteinii* (Selenka) and other species is very simple because of the thin and transparent body wall. A small piece of the body wall is cut, spread on a slide, slightly pressed under a cover glass, and examined under the microscope. Unlike the thick body walls of other holothurians that of *P. kefersteinii* and other species need not be macerated. All the different stages of anchor and anchor-plate formation, from the earliest to the fully formed spicules, can be seen. Measurements of the different stages of development are taken by means of a micrometer ocular. Measurements are made from different individuals as well as from different regions of one particular individual. The measurements obtained are almost the same in a particular stage of development.

THE DEVELOPMENT OF THE ANCHOR

The anchor develops from a simple dagger-shaped fundament, which is pointed at the posterior end and truncated at the other (Plate 1, figs. 1 and 2). This rod constitutes the shaft or body of the future anchor. In *P. kefersteinii* the youngest rod is 0.1 mm long. The stock of the anchor develops from the pointed, posterior end of the rod, while the arms are formed from the two lateral angles of the truncated, anterior end. The anterior end, which has a width of 0.007 mm, is the anlage of the arms. The study of the different stages of development shows that the shaft and the anlage of the arms gradually increase in length. The pointed end of the shaft remains pointed until the shaft reaches a length of 0.32 mm, when it becomes truncated and flattened. This recently converted, flattened, posterior end soon expands and develops into the stock or handle of the anchor. The stock grows laterally and gradually up to 0.067 mm, when it becomes finely spinous or branched as the case may be. Long before the appearance of the anlage of the stock, the anlage of the arms has grown laterally, and gives the spicule the appearance of a sword without a handle. When these lateral appendages reach a length of 0.015 mm they begin to curve medially and posteriorly and give the spicule the appearance of an anchor. The arms cease to grow after reaching a length of 0.15 mm and the anchor is considered fully formed excepting for the absence of serrations or finely knobbed teeth. These appear later at the outer edge of the arms or at the vertex. A fully formed anchor in *Polyplectana kefersteinii* has the following measurements:

	mm.
Shaft, length	0.29
Stock, length	0.067
One arm, length	0.15
Anchor, from stock to vertex, length	0.35

The mode of development of the anchor in the four species of synaptids studied—namely, *Polyplectana kefersteinii* (Selenka), *Euapta godeffroyi* (Semper), *Opheodesoma spectabilis* var. *puerto galeræ* var. nov., and *Synapta maculata* (Chamisso and Eysenhardt)—is identical (Plate 1, figs. 13 to 16). Slight differences, however, may be seen in the form of the stock (either spinous or branched), in the curvature of the arms, and in the presence or absence of serrations or knobbed teeth at the vertex or on the arms.

THE DEVELOPMENT OF THE ANCHOR PLATE

The anchor plate starts its development from a very simple rod lying at right angles to the anlage of the shaft. In *Polyplectana kefersteinii* the smallest, and what is considered to be the youngest rod is 0.03 mm long and 0.0037 mm thick (Plate 1, fig. 1). At the earliest stage this rod is truncated at both ends. Later it bifurcates at both ends and assumes the appearance of a double wrench. The original rod constitutes the primary axial rod. Its upper processes after bifurcation become the first primary arms, and the lower processes, the secondary axial rods. Each process gradually increases in length and, after reaching a length of 0.037 mm, divides dichotomously. The first primary arms give off the medial and lateral first secondary arms, while the secondary axial rods give

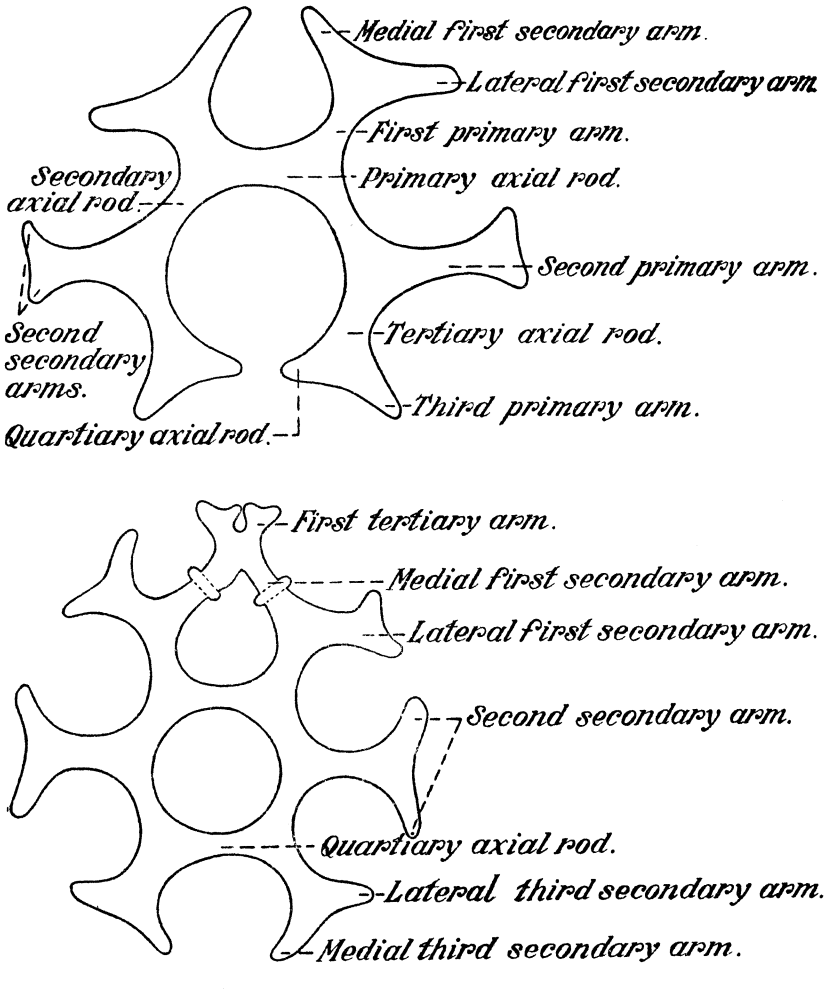

FIG. 1. *Polyplectana kefersteinii* (Selenka); early stages in the development of the anchor plate.

rise to the second primary arms and the tertiary axial rods. The two latter grow up to 0.037 mm long, and each divides dichotomously. The second primary arms give rise to the two second secondary arms, and the tertiary axial rods give rise to the third primary arms and the quartiary axial rods. These branches all grow gradually. The third primary arms divide dichotomously into the two third secondary arms. The two quartiary axial rods after reaching their maximum length fuse and thus form a complete central axial ring with the primary, secondary, and tertiary axial rods. From this central axial ring extend the three pairs of primary arms.

As the first secondary arms appear first they reach their maximum length first. The two medial first secondary arms fuse together to form an inverted heart-shaped ring from the apex of which two upright branches, the first tertiary arms, arise very close together. These two upright branches divide dichotomously and give rise to smaller branches, the medial ones of which fuse and inclose a small oval cavity. Anterior and lateral to the point of fusion three to four small branches are given off, each of which divides dichotomously. All these terminal branches fuse and inclose a series of three or four tiny perforations which mark the handle of the plate (text fig. 2).

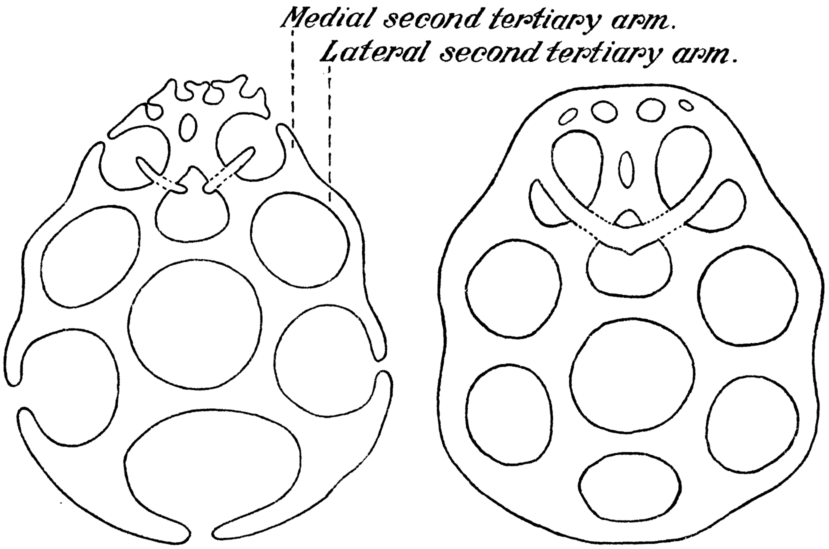

FIG. 2. *Polyplectana kefersteinii* (Selenka); late stages in the development of the anchor plate.

A thickening appears across the median portion of each medial first secondary arm. These are the anlagen of the bow. These thickenings elongate laterally and medially until they fuse to form a curved bar crossing the apex of the inverted heart-shaped ring. At the same time the lateral first secondary arms divide dichotomously, giving rise to the medial and lateral second tertiary arms (text fig. 2).

The lateral second tertiary arm together with the second and third secondary arms steadily fuse and inclose the five large peripheral rings that surround the central axial ring. The lateral extensions of the anlagen of the bow at this time also grow laterally to fuse with the outer ring, and divide the two large peripheral rings at the posterolateral sides of the inverted heart-shaped ring into two unequal parts (fig. 2, *b*).

Serrations then appear around the inner margin of the central axial ring and of the five large peripheral rings. The part of the bow that crosses the inverted heart-shaped ring also develops a few serrations at its anterior margin. Then the anchor plate assumes its final form.

The total length of the plates averages 0.22 mm. The maximum width is 0.17 mm. The posterior part, considered to be the handle of the plate, is narrower than the body and measures 0.087 mm.

The development of the anchor and the anchor plate is identical in all the synaptids studied from Puerto Galera. Even in *Synapta maculata,* Plate 1, fig. 20, in which the fully formed anchor plate is very different from that of the other species, the development is of the same plan. Slight modifications only appear later in the irregular ramifications of the tertiary and quartiary arms at the anterior and posterior ends of the plates, which result in the formation of numerous small perforations.

RELATIONS OF THE ANCHOR AND THE ANCHOR PLATE

The anchor and the anchor plate are closely related to each other. They are always found lying one over the other. Even in the earliest stage of development the rod-shaped fundament of the anchor plate is always found lying at right angles to the anlage of the anchor near its anterior end. They do not become separated from each other except through pressure, because they are connected by a loose connective tissue. This is seen when a piece of body wall is mounted on a slide and examined under the microscope. They only become separated from each other when the body wall is macerated.

SUMMARY AND CONCLUSIONS

1. The spicules in synaptids of the order Paractinopoda or Apoda develop from a simple rod-shaped fundament unlike those in holothurians of the order Actinopoda or Pedata, which develop from an X-shaped fundament.

2. The anchor and the anchor plate of synaptids, though different in shape, are both derived from a single straight fundament.

3. In all other species, including *Synapta maculata,* where the anchor plate is very different in shape from the others, the plan of development is the same.

4. The anchor and the anchor plate are closely related to each other and are always found lying at right angles, one over the other, even in the earliest stages. They are bound together by some kind of loose connective tissue.

ACKNOWLEDGMENT

The writer is indebted to Dr. Hilario A. Roxas, head of the Department of Zoölogy, for reading this paper, and to Dr. Leopoldo S. Clemente, of the same department, for some constructive suggestions.

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ILLUSTRATIONS

PLATE 1

FIGS. 1 to 11. *Polyplectana kefersteinii* (Selenka); stages in the development of the anchor and the anchor plate.

FIG. 12. *Polyplectana kefersteinii* (Selenka); miliary granules; *a*, from an adult individual; *b*, from a younger individual.

13. *Euapta godeffroyi* (Semper); fully formed anchor.
14. *Polyplectana kefersteinii* (Selenka); fully formed anchor.
15. *Opheodesoma spectabilis* var. *puerto galeræ* var. nov.; fully formed anchor.
16. *Synapta maculata* (Chamisso and Eysenhardt); fully formed anchor.
17. *Euapta godeffroyi* (Semper); fully formed anchor plate.
18. *Polyplectana kefersteinii* (Selenka); fully formed anchor plate.
19. *Opheodesoma spectabilis* var. *puerto galeræ* var. nov.; fully formed anchor plate.
20. *Synapta maculata* (Chamisso and Eysenhardt); fully formed anchor plate.

TEXT FIGURES

FIG. 1. *Polyplectana kefersteinii* (Selenka); early stages in the development of the anchor plate.

2. *Polyplectana kefersteinii* (Selenka); late stages in the development of the anchor plate.

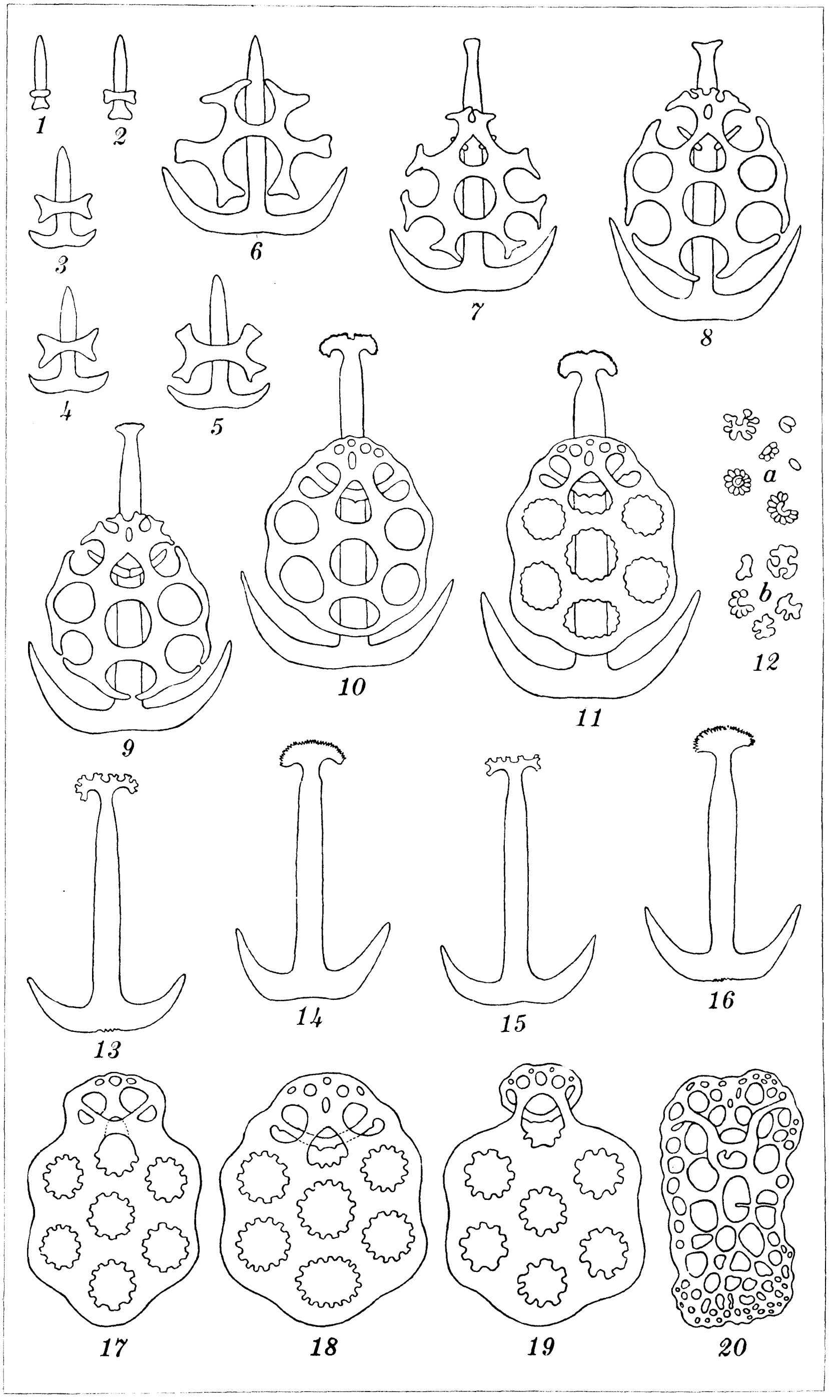

PLATE 1.

NEMATODES PARASITIC IN PHILIPPINE COCKROACHES

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THREE PLATES

Through the courtesy of Dr. J. H. Sandground, of the School of Tropical Medicine, Harvard University, the writers have recently had an opportunity to study a small collection of nematodes from *Panesthia javanica,* a cockroach native to the Philippines. This material contained five species, one of which appears to be very close to *Blattophila sphaerolaima* Cobb, 1920, a species that B. G. Chitwood (1932) recently placed in the Thelastomatidæ, as a genus and species inquirenda. For this nematode the writers propose the name *Blattophila sphaerolaima* var. *javanica,* since it differs only in minor respects from the form described by Cobb (1920). The remaining four species appear to be new and represent four genera, three of which have been previously described. One species appears to be most closely related to *Aorurus agile* (Leidy, 1849) but to differ from that species very strikingly. The name *Aorurus philippinensis* is proposed for this species. For two of the species, which appear to belong to the genera *Thelastoma* and *Leidynema,* respectively, the names *Thelastoma palmettum* and *Leidynema nocalum* are proposed.

The fifth species appears to represent a new genus most closely related to *Leidynema,* for which the name *Leidynemella paracranifera* is proposed.

In addition to the foregoing, a description of a new species written by the late Dr. N. A. Cobb is included. Doctor Cobb's notes on nematode parasites of cockroaches were turned over to the writers by his daughter, Miss Margaret V. Cobb. Doctor Cobb had originally intended this species to be the type of a new genus, with which view the writers agree. However, in view of the absence of figures and some other pertinent data in Doctor Cobb's notes, the writers designate another species as type of the genus. Doctor Cobb's species appears in this paper under the name *Leidynemella fusiformis* Cobb, new species.

Because of certain changes made necessary in the diagnoses of the genera belonging to the subfamily Thelastomatinæ, due to the discovery of the new species described in this paper, it is desirable to formulate a new key to the genera of this subfamily.[1]

Genus BLATTOPHILA Cobb, 1920

Generic diagnosis.—Thelastomatinæ: Oral opening surrounded by eight labiopapillæ; amphids represented externally by small round openings at level of labiopapillæ. Lateral alæ absent. Buccal cavity short and wide, partially surrounded by anterior end of œsophagus and having at base six cuticular thickenings serving as points of attachment for muscles. Œsophagus consists of (1) a clavate corpus distinctly enlarged at anterior end in form of a subspherical swelling, and (1*a*) a posterior part slightly swollen but not set off, (2) a short, narrow, isthmus, and (3) a bulb. Excretory pore posterior to base of œsophagus. Intestine dilated at anterior end; cœcum absent. Tail of male truncate, conical, bearing two large preanal submedian papillæ adjoining anus, and two similar postanal papillæ, one-third of a body diameter, posterior to anus. Spicule represented by a rudimentary point. Tail of female filiform and spinelike. Vulva anterior to middle of body. Eggs ellipsoidal.

Type species.—*Blattophila sphaerolaima* Cobb, 1920.

BLATTOPHILA SPHAEROLAIMA var. JAVANICA var. nov. Plate 1, figs. 1 to 3.

Specific description.—*Blattophila:*

Male unknown.

Female (nongravid) 2.5 to 2.63 mm long by 250 to 273 μ in maximum width. Cuticle coarsely annulated; annules 8 to 10 μ wide near head and 26 to 28 μ wide at mid-region of body. Buccal cavity short, subtriangular in cross section, inclosed in anterior end of œsophagus and provided with two subdorsal and four subventral cuticular thickenings at base (presumably the "apophyses" of Cobb). Œsophagus 410 to 610 μ long; cephalic swelling of œsophagus 33 to 50 μ long by 35 to 44 μ wide, corpus 280 to 360 μ long with a minimum diameter of 34 to 40 μ and a maximum diameter of 56 to 70 μ; isthmus 30 to 40 μ long by 28 to 30 μ wide; bulb 100 to 120 μ long by 80 to 97 μ wide. Nerve ring not observed. Excretory pore immediately posterior to base of œsophagus. Intestine thick-walled with a short dilated part, posterior to œsophageal bulb. Anus 590 to 670 μ from posterior end of body. Phasmids slightly posterior to anus. Tail filiform, spicate. Vulva 550 to 750 μ from anterior end of body, 21 to 23.6 per cent of body length from anterior end. Vagina directed posteriorly, true vagina (cuticularly lined) approximately 130 μ long; origin of uteri uncertain; two ovaries, directed posteriorly, reflexed. Eggs not observed.

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[1] It appears necessary, according to the rules of the International Commission on Zoölogical Nomenclature, to emend the spelling of the names Thelastomidæ Travassos, 1929, and Thelastominæ Travassos, 1920, the correct names being Thelastomatidæ Travassos, 1929, emend., and Thelastomatinæ Travassos, 1920, emend.

Host.—*Panesthia javanica.*

Location.—Presumably intestine.

Type locality.—Philippine Islands.

Type specimen.—United States National Museum helminthological collection No. 33045; paratypes No. 33046.

The structure of this nematode appears to agree with the original description of *Blattophila sphaerolaima* Cobb, with the following exceptions: (*a*) The vulva is relatively farther anterior than in Cobb's specimens (21 to 23.6 per cent as against 28 per cent); (*b*) the cuticular annules at the anterior end of the body are wider (8 to 10 μ wide as against 3 μ wide); and (*c*) the cuticular annules are wider in the mid-region of the body (26 to 28 μ wide as against 24 μ wide). The writers do not consider any of these characters sufficient for the erection of a species in the present case, since these measurements are based upon only two specimens, and the reader may see from the variation in the above measurements that additional specimens might readily increase the range.

Genus AORURUS Leidy, 1849

Generic diagnosis.—Thelastomatinæ: Oral opening surrounded by an external circle of eight equal labiopapillæ or papillæ. Amphids represented externally by small round or oval openings at level of external circle of papillæ. Buccal cavity very short and wide. Œsophagus with short, thick corpus in female, forming a pear-shaped swelling; isthmus short or long. Excretory pore near base of œsophagus or posterior to base of œsophagus. Intestine without cæcum. Tail of male filiform.

Genital papillæ consisting of two pairs of papillæ just anterior to anus, one pair more or less fused; one pair of partially fused postanal papillæ, just posterior to anus; and one pair of papillæ on tail. Spicule absent. Testis reflexed. Tail of female filiform (more spinelike). Vulva either near middle of body or near anus; vagina directed anteriorly, uteri divergent, ovaries reflexed. Eggs ellipsoidal; polar cap apparently absent.

Key to the species of the genus Aorurus.

Corpus of female approximately one-half total length of œsophagus; isthmus very short, merely a constricted region between corpus and bulb; vulva just anterior to anus .... *A. agile.*

Corpus of female approximately one-third total length of œsophagus; isthmus approximately three-eighths total length of œsophagus; vulva near middle of body .... *A. philippinensis* sp. nov.

The genus *Aorurus* was originally proposed for two species, *A.* (*Streptostoma*) *agile* Leidy, 1849 and *A.* (*Thelastoma*) *attenuatum* Leidy, 1849. Subsequently the subgenus *Thelastoma* was raised by Leidy (1853) to generic rank and later *Blattophila sphaerolaima* Cobb, 1920 was placed in the genus *Aorurus* by Travassos (1929). As will be seen later, this decision was in error. *Aorurus subcloatus* Christie (1931) has been shown to be a synonym of *Aorurus agile* (Leidy, 1849) (see Chitwood, 1932). *Aorurus diesingi* (Hammerschmidt, 1838) Travassos, 1929 was made the type of a new genus *Hammerschmidtiella* by Chitwood (1932). The new species *Aorurus philippinensis* necessitates a somewhat revised conception of the genus *Aorurus* since the vulva is in the middle of the body instead of in front of the anus, as is the case in the type species. The females of these two genera may be distinguished by the structure of the œsophagus, since in both species of *Aorurus* the entire corpus enters into the formation of the corporeal swelling, there being no distinguishable differentiation between the anterior and posterior parts of the corpus, while in *Hammerschmidtiella* only the posterior part of the corpus forms the swelling, the anterior and posterior parts being, therefore, easily differentiated.

AORURUS PHILIPPINENSIS sp. nov. Plate 2, figs. 7 to 11.

Specific description.—Aorurus:

Male unknown.

Female 4 to 4.45 mm long by 165 to 270 μ in maximum width, widest specimen somewhat flattened. Cuticle both annulated and striated. Head distinctly set off by a deep annulation followed by a long, modified first annule of body (Plate 2, fig. 9), posterior to which the cuticle is coarsely annulated and inflated; annules 17 to 35 μ wide; each annule finely striated, striæ 2 to 5 μ apart; annules gradually becoming less distinct in mid-region of body. Oral opening hexangular, apices of angles submedian and lateral rather than median and sublateral. Cephalic papillæ apparently consisting of an internal circle of six rudimentary papillæ and an external circle of eight well-developed simple papillæ. Œsophagus 473 to 540 μ long, consisting of a pear-shaped corpus, 160 μ long with a minimum diameter of 56 to 60 μ and a maximum diameter of 84 to 110 μ; a narrow isthmus 216 to 260 μ long by 35 to 40 μ wide; and a bulb 130 μ long by 120 to 124 μ wide. Nerve ring posterior to base of corpus. Excretory pore 840 μ from anterior end of body. Intestine dilated at base of œsophagus. Anus 735 to 800 μ from posterior end of body. Tail filiform (spicate). Phasmids approximately one-half of a body diameter posterior to anus. Vulva 1.82 to 2.18 mm from anterior end of body; prominent, anterior lip projected posteriorly; true vagina 150 to 160 μ long, lined with cuticle; uterine vagina about 250 μ long; uteri divergent; anterior ovary directed posteriorly and reflexed anteriorly, posterior ovary directed anteriorly and reflexed posteriorly. Eggs ellipsoidal, 164 to 166 μ long by 70 to 80 μ wide.

Host.—*Panesthia javanica.*

Location.—Presumably intestine.

Type locality.—Philippine Islands.

Type specimen.—United States National Museum helminthological collection No. 33047; paratypes No. 33048.

This species differs from *A. agile* in that the corpus is proportionately shorter than in *A. agile,* the isthmus is proportionately much longer, the excretory pore is situated farther posterior, and the vulva is situated more anterior than in *A. agile.*

THELASTOMA PALMETTUM sp. nov. Plate 1, figs. 4 to 6.

Specific description.—*Thelastoma:*

Male unknown.

Female (nongravid) 1.12 to 1.92 mm long by 140 to 150 μ maximum width. Oral opening subtriangular, surrounded by an external circle of eight labiopapillæ; internal circle not observed. First annule 42 to 53 μ wide; remaining annules 8 to 10 μ wide. Buccal cavity short and wide, containing one dorsal and two subventral anteriorly projecting cuticular structures shaped somewhat like palm leaves. Œsophagus 618 to 636 μ long, consisting of a corpus 440 to 550 μ long by 20 μ wide, an isthmus 32 μ long by 16 μ wide, and a bulb 60 μ long by 60 μ wide. Nerve ring 220 μ and excretory pore 450 μ from anterior end of body (observed in only one specimen). Intestine distinctly enlarged at anterior end. Anus 560 to 680 μ from posterior end of body; tail attenuated, becoming filiform. Vulva 772 μ to 1.0 mm from anterior end of body; vagina directed anteriorly; uteri divergent, anterior ovary directed posteriorly and reflexed anteriorly; posterior ovary directed anteriorly, reflexure not observed.

Host.—*Panesthia javanica.*

Location.—Presumably intestine.

Type locality.—Philippine Islands.

Type specimen.—United States National Museum helminthological collection No. 33049; paratypes No. 33050.

This species may be differentiated from other known species of the genus *Thelastoma* by the characteristic palm-leaflike cuticular projections in the buccal cavity. While it is probable that homologous structures are present in other species of the genus, no species is known to have such an elaborate formation.

LEIDYNEMA NOCALUM sp. nov. Plate 2, figs. 12 and 13; Plate 3, figs. 14 to 17.

Specific description.—*Leidynema:*

Male 1.1 to 2.33 mm long by 80 to 100 μ wide. Cuticular bosses and alæ apparently absent. Oral opening hexangular, surrounded by an internal circle of six small papillæ and an external circle of eight large papillæ. Amphids lateral, porelike. Buccal cavity short, subtriangular in cross section. Œsophagus 290 to 294 μ long; the anterior part of corpus 100 to 104 μ long by 18 to 24 μ wide, posterior part 60 μ long by 30 to 36 μ wide; isthmus 38 to 50 μ long by 8 to 10 μ wide; bulb 80 μ long by 54 to 70 μ wide. Nerve ring and excretory pore not observed. Anus 590 to 600 μ from posterior end of body; tail attenuated, becoming filiform. Caudal papillæ consisting of one pair of large preanal papillæ, one pair of small adanal papillæ, a medioventral postanal organ, and a pair of postanal papillæ near anus. Short, narrow, preanal subventral alæ. Spicule absent.

Female (nongravid) 1.84 to 2.2 mm long by 80 to 100 μ wide. Lateral alæ absent. Oral opening subtriangular; internal circle of papillæ not observed; external circle consisting of eight labiopapillæ; amphids oval. Buccal cavity and œsophagus shaped as in male. Œsophagus 240 to 260 μ long; anterior part of corpus 100 μ long by 22 μ wide, posterior part 60 μ long by 40 μ wide; isthmus 30 μ long by 22 μ wide; and bulb 50 μ long by

70 μ wide. Intestine without cæcum or posterior twist. Anus 520 to 560 μ from posterior end of body. Tail finely attenuated, not set off from body. Vulva 600 to 650 μ from anterior end of body; uteri apparently first parallel, directed anteriorly, then divergent.

Host.—*Panesthia javanica.*

Location.—Presumably intestine.

Type locality.—Philippine Islands.

Type specimens.—United States National Museum helminthological collection No. 33051; paratypes No. 33052.

The most outstanding character by which *L. nocalum* may be distinguished from the remaining species of the genus *Leidynema* is the presence of a distinct posterior swelling of the corpus in both sexes. Previously, no species of thelastomid has been described in which the œsophagus of the male possesses a corporeal swelling. The similarity of the œsophagus of thelastomid males [that is, *Aorurus agile* (syn. *A. subcloatus*) as shown by Christie, 1931] to that of the larvæ of females rather than to the adult, as well as the sexual dimorphism of cephalic characters, have led to the conclusion that most thelastomid males may be considered precocious larvæ. In this connection, it is interesting to note that *L. nocalum* is the first species found in which the œsophagus is identical in both sexes; there is also much less sexual dimorphism in cephalic characters.

The female of *L. nocalum* may be differentiated from females of other species of the genus through the proportionately greater length of the isthmus which is indicated by only a very short constriction in other members of the genus. Further differentiation of the species is shown in the following key.

Key to the species of the genus Leidynema.

1. Buccal cavity subcylindrical, twice as long as wide............ *L. craniferum.*
   Buccal cavity not longer than wide.. 2.
2. Lateral alæ of female large, terminating posteriorly in paired lateral spines .... *L. appendiculatum.*
   Lateral alæ of female narrow or absent, not terminating in paired lateral spines .... 3.
3. Tail of female short and conical with only slight attenuation. *L. delatorrei.*
   Tail of female long and finely attenuated............................ *L. nocalum.*

Genus LEIDYNEMELLA gen. nov.

Generic diagnosis.—Thelastomatinæ: Male unknown in type species. In known species, one testis, reflexed, tail very abruptly set off from remainder of body, appearing as a dorsal appendage. Spicule single. Caudal papillæ consisting of one pair of preanal papillæ near anus, one medioventral postanal papilla, and a pair of subdorsal postanal papillæ near anus. Female with narrow lateral alæ; cuticular annulations small but conspicuous. Oral opening surrounded by eight submedian labiopapillæ; amphids lateral, small. Buccal cavity short, prismoidal. Œsophagus consisting of (1) a long narrow corpus terminated by (1*a*) a subspherical swelling, (2) a distinctly set-off isthmus, and (3) a bulb. Nerve ring apparently surrounding middle of corpus. Excretory pore not observed. Intestine dilated anteriorly, then becoming narrow; diverticula absent. Tail filiform. Vulva approximately half way from head to anus; vagina directed posteriorly; uteri apparently divergent. Egg not observed.

Type species.—*Leidynemella paracranifera* sp. nov.

The genus *Leidynemella* appears to be most closely related to the genus *Leidynema* but differs from the latter in that the swelling at the base of the corpus is subspherical rather than subcylindrical. The type species, *L. paracranifera* sp. nov., resembles *Leidynema craniferum,* but differs from that species chiefly in the shape of the corporeal swelling. The writers have also placed in the new genus *Leidynemella* the species *Oxyuris panesthiæ* Galeb, 1878 [=*Leidynemella panesthiæ* (Galeb, 1878) new comb.] and *Leidynemella fusiformis* Cobb sp. nov. These three species agree in the character of the œsophagus.

LEIDYNEMELLA PARACRANIFERA sp. nov. Plate 3, figs. 18 and 19.

Specific description.—*Leidynemella:*

Male unknown.

Female (nongravid) 1.6 mm long by 120 μ wide. Lateral alæ not terminated posteriorly by spines. Cuticular annules 10 μ wide in mid-region of body; head set off as three modified annules (see fig. 18); cephalic papillæ as in *Leidynema craniferum.* Buccal cavity prismoidal, bearing cuticular thickenings near base. Œsophagus 226 μ long; anterior part of corpus 130 μ long by 16 μ wide, posterior part 30 μ long by 28 μ wide; isthmus 30 μ long by 12 μ wide; bulb 36 μ long by 32 μ wide. Nerve ring apparently 100 μ from anterior end of body. Anus 630 μ from posterior end of body. Vulva 450 μ from anterior end of body.

Host.—*Panesthia javanica.*

Location.—Presumably intestine.

Type locality.—Philippine Islands.

Type specimen.—United States National Museum helminthologial collection No. 33053.

Leidynemella paracranifera differs from *Leidynemella panesthiæ* in that the vulva is near the middle of the body, exclusive of the tail, in the new form, while it is definitely posterior to the middle of the body, exclusive of the tail, in the latter species. The two species may be further differentiated by the relative length of the anterior part of the corpus and isthmus. In *L. panesthiæ* the istmus is three-fourths as long as the anterior part of the corpus, while in *L. paracranifera* the isthmus is only ten forty-thirds as long as the anterior part of the corpus.

LEIDYNEMELLA FUSIFORMIS N. A. Cobb,[2] sp. nov.

Specific description.—Leidynemella:

Male more slender and less fusiform than female. Œsophagus not described; presumably as in female. Tail set off from body by abrupt diminution in size, almost as if attached as an appendage to the dorsal side of a terminal anus; it is only two to five times as long as neck but like that of female, is slender and pointed. Caudal papillæ consisting of two subventral preanal papillæ near anus, one medioventral postanal papilla near anus, and two subdorsal papillæ near anus. Testis extending one-half distance from anus to base of œsophagus; reflexed. Spicule straight, linear, equal to anal body diameter in length. Caudal alæ absent.

$$\text{Female } \frac{.8 \quad 11. \quad 15.5 \quad 27. \quad 57.}{1.2 \quad 4.1 \quad 5.2 \quad 7.1 \quad 3.} 1.5 \text{ mm long by } 106\ \mu \text{ wide.}$$

Striæ plain, transverse, giving contour of worm a crenate appearance, changing somewhat in cervical region to become almost retrorsely serrate. Striæ 2.3 μ apart in cervical region; 3 to 5 μ apart near middle of body. Neck conoid; two prominent pointed lateral retrorse spines, situated one-half to three-fifths distance from anterior end to swelling at base of corpus; lateral alæ terminated posteriorly by paired lateral spines opposite anus. Appearance of head varying widely dependent upon whether it is at rest or in action. Generally appearing somewhat truncate and not expanded, but appearing to contain a hollow sphere through which the lining of the œsophagus is seen to pass. Head, however, often appearing swollen as if wearing a fez or a crown. In this condition the organs ordinarily seen to lie inside the head are everted. Cephalic setæ,

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[2] Description by N. A. Cobb; edited by the present writers.

papillæ, eye spots, and amphids not observed. Buccal cavity resembling that of *Diplogaster,* half as deep as head is wide and two-thirds as wide as deep; this does not apply to the ordinary appearance of the buccal cavity when the parts are at rest, but to the everted condition. Distance to base of œsophagus 232 µ. Œsophagus resembling that of *Diplogaster,* having a median and a cardiac bulb, both well developed; subspherical median bulb at beginning of posterior third of œsophagus, two-thirds as wide as corresponding part of neck; posterior bulb nearly spherical, larger, two-thirds as wide as base of neck, containing a large and elaborate valve; isthmus one-fifth to one-fourth as wide as corresponding part of neck and somewhat longer than cardiac bulb. Nerve ring 165 µ from anterior end of body. Excretory pore not observed. Narrow, deep, and distinct cardiac column between colorless intestine and œsophagus; intestine dilated at anterior end. Rectum hardly as long as anal body diameter. Anus 755 µ from posterior end of body; tail diminished very suddenly, on ventral side a little behind anus, very soon becoming only one-half as wide as at anus; tapering to a point. Vulva 305 µ from anterior end of body; vagina directed anteriorly, reflexed posteriorly; uteri extending backward to vicinity of anus then reflexed. Ovaries half as long as body of worm, blind ends lying near vulva. Eggs thin-shelled, 90 to 100 µ long by 36 µ wide, slightly curved, segmented; approximately 12 in number.

Host.—*Panesthia laevicollis* (?).

Location.—Intestine.

Type locality.—Moss Vale, New South Wales, Australia (1894).

Type specimens.—Probably lost.

Leidynemella fusiformis differs from *L. panesthiæ* in that the vulva is anterior to the middle of the body, exclusive of the tail, and lateral alæ terminating in spines are present in the female, none having been described in *L. panesthiæ. Leidynemella paracranifera* may be differentiated from *L. fusiformis* by the apparent absence of spinate terminations of the alæ as well as by the greater width of the annules, which are 10 µ wide in the middle of the body, while those of *L. fusiformis* are only 3 to 5 µ wide.

The differences of the three species of the genus *Leidynemella* are shown in the following key.

Key to the species of the genus Leidynemella.

1. Vulva posterior to middle of body (exclusive of tail).... *L. panesthiae.*
   Vulva anterior to or near middle of body, exclusive of tail.................... 2.
2. Lateral alæ of female terminating anteriorly and posteriorly as spinate processes; cuticular annules not over 5 μ wide............ *L. fusiformis.*
   Lateral alæ not terminating in spinate processes; cuticular annules 10 μ wide near middle of body.................................... *L. paracranifera.*

For the purpose of differentiating the genera at present included in the subfamily Thelastomatinæ, the following key is appended.

Key to the genera of the subfamily Thelastomatinæ.

1. Corpus of œsophagus terminated posteriorly by a pronounced swelling, at least in female .... 2.
   Corpus of œsophagus not terminated by pronounced swelling................ 5.
2. Anterior and posterior parts of corpus not distinctly set off.... *Aorurus.*
   Anterior and posterior parts of corpus distinctly set off......................... 3.
3. Corpus terminated by a subcylindrical swelling.................... *Leidynema.*
   Corpus terminated by an ovoid or subspherical swelling.................... 4.
4. Buccal cavity well developed; corpus terminated by a subspherical swelling .... *Leidynemella.*
   Buccal cavity extremely small and short; corpus terminated by an ovoid swelling .... *Hammerschmidtiella.*
5. Eggs encapsulated or covered with spiral threads (often in two's or three's) .... 6.
   Eggs not covered as above .... 7.
6. Eggs covered by spiral threads .... *Pseudonymus.*
   Eggs encapsulated, not covered by spiral threads........................ *Binema.*
7. Corpus of œsophagus of female very short, club-shaped........ *Blatticola.*
   Corpus of œsophagus of female not very short, not club-shaped........ 8.
8. Corpus distinctly enlarged in form of a subspherical swelling at base of buccal cavity .... *Blattophila.*
   Corpus subcylindrical, without any form of distinct enlargement........ 9.
9. Tail conical or nearly conical in both sexes.. 10.
   Tail filiform, attenuated then delicately filiform, or very sharply set off in both sexes .... 11.
10. Head of female with dorsodorsal and ventroventral simple papillæ and laterodorsal and lateroventral labiopapillæ......................... *Severianoia.*
    Head of female with all eight cephalic papillæ in form of labiopapillæ. *Cephalobellus.*
11. Female with one ovary.. *Galebia.*
    Female with two ovaries .... 12.
12. Tail of female in form of a short appendage......................... *Suifunema.*
    Tail of female filiform or very delicately attenuated......................... 13.
13. Oral opening surrounded by three lips...................................... *Fontonema.*
    Oral opening not surrounded by three lips.. 14.

14. Tail of male extremely short, degenerate............................... *Euryconema.*
Tail of male delicately attenuated or filiform........................ *Thelastoma.*

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ILLUSTRATIONS

PLATE 1

BLATTOPHILA SPHAEROLAIMA VAR. JAVANICA VAR. NOV.

FIG. 1. Female, head, en face view.
2. Female, œsophageal region, dorsoventral view.
3. Female, tail, lateral view.

THELASTOMA PALMETTUM SP. NOV.

FIG. 4. Female, head, en face view.
5. Female, head, dorsoventral view.
6. Female, anal region, oblique lateral view.

PLATE 2

AORURUS PHILIPPINENSIS SP. NOV.

FIG. 7. Female, head, en face view.
8. Female, head, oblique lateral view.
9. Female, œsophageal region, lateral view.
10. Female, tail, lateral view.
11. Egg.

LEIDYNEMA NOCALUM SP. NOV.

FIG. 12. Female, head, en face view.
13. Male, head, en face view.

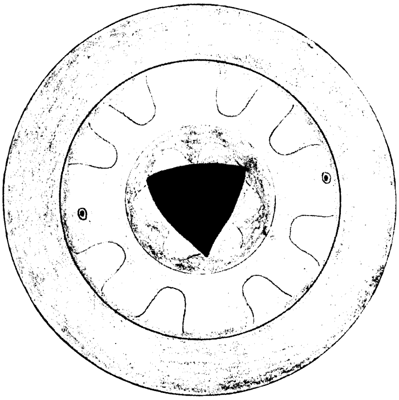
PLATE 3

LEIDYNEMA NOCALUM SP. NOV.

FIG. 14. Male, head, lateral view.
15. Male, œsophageal region, dorsoventral view.
16. Male, tail, lateral view.
17. Male, region of cloaca, ventral view.

LEIDYNEMELLA PARACRANIFERA GEN. ET SP. NOV.

FIG. 18. Female, head, lateral view.
19. Female, œsophageal region, dorsoventral view.



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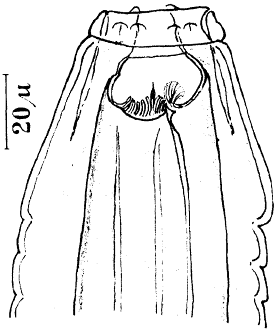

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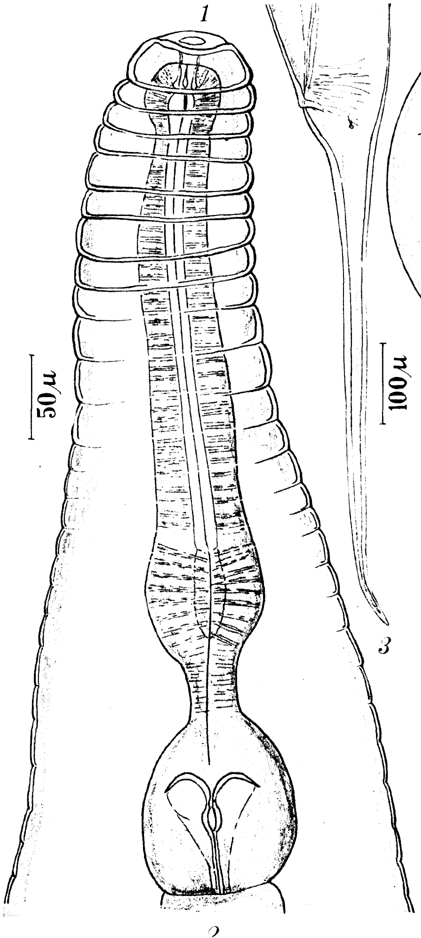

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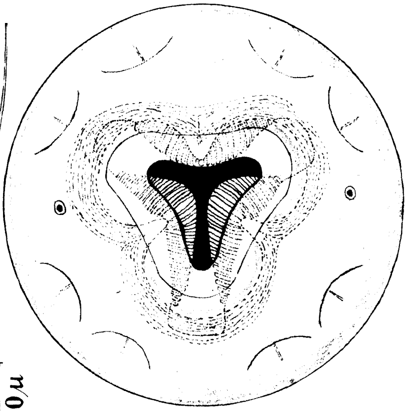

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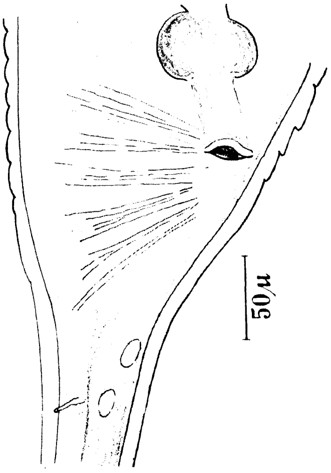

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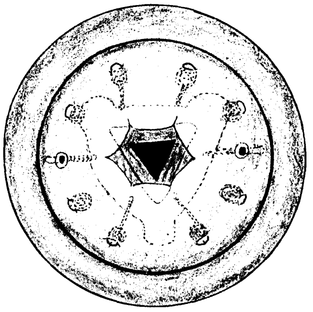
PLATE 1.



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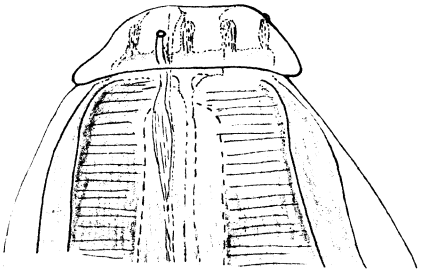

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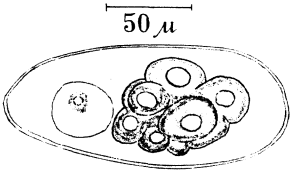

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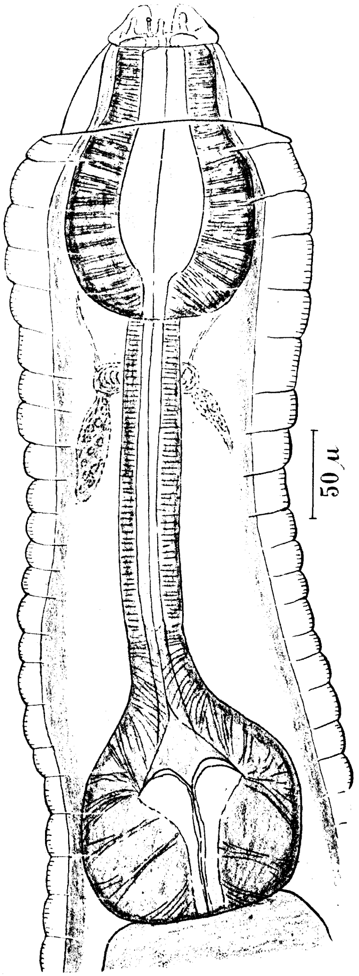

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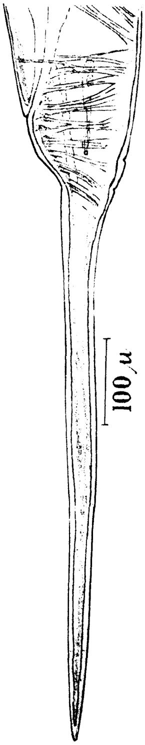

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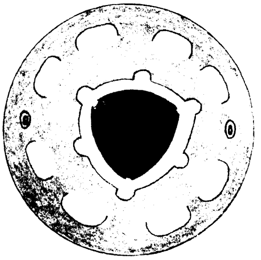

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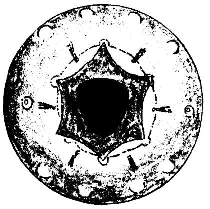

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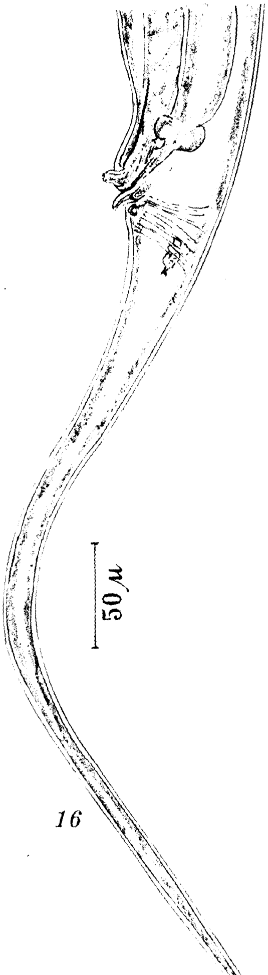
PLATE 2.

UNIV. OF IOWA



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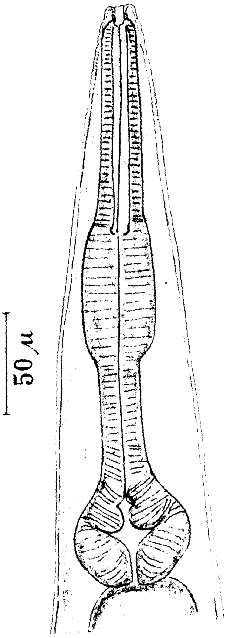

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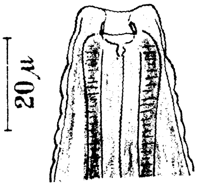

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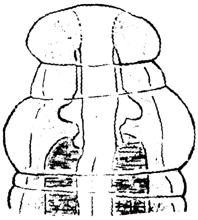

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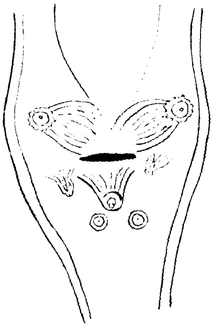

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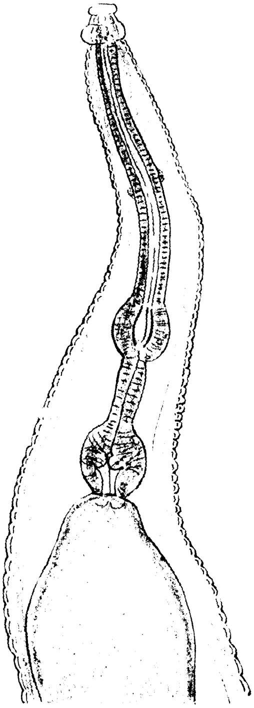

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PLATE 3.

NEW OR LITTLE-KNOWN TIPULIDÆ FROM EASTERN ASIA (DIPTERA), XVII[1]

By CHARLES P. ALEXANDER
Of Amherst, Massachusetts

FIVE PLATES

The Tipulidæ discussed at this time were included in extensive series of specimens from eastern Siberia, sent to me for determination by Dr. Theodore Pleske and Dr. A. von Stackelberg, of the Russian Academy of Sciences, Leningrad. In this report, species of the genus *Tipula* are discussed. I express my deep thanks to the entomologists and collectors mentioned in the text for the opportunity of studying this unusually interesting series of crane flies. The types of the novelties are preserved in the Russian Academy of Sciences.

There is, perhaps, no faunal region on earth where a wider acquaintance with species from many other localities is required. In eastern Siberia, in addition to the far more numerous endemic forms, there occur elements derived from three distinct sources, as follows:

1. *From the south.*—Japan and eastern China. Many species hitherto reported only from Japan are now known to range at least as far as the Ussuri, and, in cases, still farther to the north. Representatives of genera, subgenera, and species of tropical affinities reach the Ussuri, including *Pselliophora, Libnotes, Limonia* (*Rhipidia*) *pulchra* de Meijere, *Paratropesa,* and *Styringomyia.*

2. *From the west.*—Europe and western Asia. Several species of well-known European crane flies reach the Amur country unchanged; these include more especially members of the subfamily Limoniinæ, as *Tipula* (*Tipula*) *czizeki* de Jong, *Limonia* (*Dicranomyia*) *patens* (Lundström), *Pedicia* (*Pedicia*) *arctica* Frey, *Limnophila* (*Limnophila*) *pictipennis* Meigen, *L.* (*Tricholimnophila*) *punctum* Meigen, and others. Still other forms, while allied to European species, show characters deemed to

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[1] Contribution from the entomological laboratory, Massachusetts State College.

be of specific worth. In most of the last-named cases, a third vicarious species occupies boreal North America, so the various members are about equidistantly spaced throughout the boreal and subboreal portions of the Northern Hemisphere. Examples of such representative forms chosen from the genus *Tipula* are as follows:

Western Palæarctic (Europe).	Eastern Palæarctic (eastern Siberia).	Northern Nearctic (Canada).
excisa Meigen.	*excisoides* sp. nov.	*balioptera* Loew.
subexcisa Lundström.	*lundströmiana* sp. nov.	*serta* Loew.
	dershavini sp. nov.	*senega* Alexander.
vafra Riedel.	*cupida* sp. nov.	*fragilina* Alexander.
luteipennis Meigen.	*mediolobata* sp. nov.	
quadrivittata Staeger.	*subsulphurea* Alexander.	*sulphurea* Doane.

Certain genera and subgenera, as *Acutipula* Alexander, *Thaumastoptera* Mik, *Limnophila* Meigen, sensu strictu, and *Tricholimnophila* Alexander, occupy the entire northern Palæarctic Region but apparently have not reached the American continent.

3. *From the east.*—Alaska and the Canadian northwest. A growing list of species falls in this category, including *Tipula macrolabis* Loew, *Limonia* (*Discobola*) *argus* (Say), *L.* (*D.*) *platyrostra* Alexander, and *Limnophila unica* Osten Sacken. In Asia such species occur in Kamchatka and southward and have evidently been distributed via the Aleutian and Commodore Islands, rather than to the northward across the narrower Bering Strait.

In addition to all the above, there is found a considerable number of very widespread forms that range throughout the entire Holarctic Region, including hardy representatives of *Limonia, Helobia, Trimicra,* and other genera.

TIPULINÆ

Genus TIPULA Linnæus

Tipula Linnæus, Systema Naturæ, ed. 10 (1758) 585.

Subgenus VESTIPLEX Bezzi

Tipula (*Vestiplex*) Bezzi, Ann. Mus. Civ. Stor. Nat. Genova **51** (1924) 230–231.

Tipula (*Vestiplex*) Edwards, Ann. & Mag. Nat. Hist. X **8** (1931) 79–80.

Numerous species of *Vestiplex* are found throughout the Holarctic Region. The characters of the group have been recast by Edwards in the paper cited above, and it is my purpose here only to note a few additional points concerning the details of structure of the male hypopygium.

The caudal portion of the ninth tergite is often, if not usually, heavily sclerotized and blackened, forming a more or less distinct shallowly depressed area with narrow raised rims that is herein discussed as the "tergal saucer." Behind this saucer, less heavily thickened portions of the tergite occur, the median line being almost invariably more membranous. In a number of species of *Vestiplex,* the tergal saucer tends to swing ventrad so as to lie on the lower face of the tergite, in which case the only part of the sclerite visible from above is the feebly sclerotized cephalic portion, together with the cephalic rim of the saucer, where this is developed. In such cases, when treated with caustic soda, the saucer swings dorsad and cephalad so as to assume its normal position. This curious occurrence was first noted by Mr. Edwards, and unless appreciated may cause confusion in the separation of allied species. In most species of *Vestiplex,* the blackened tergal saucer occupies the caudal half or more of the tergite; in a few species, as *tchukchi* sp. nov., the saucer is so extensive that it embraces the entire mid-dorsal area of the tergite. In other forms, the saucer is pale yellow, only feebly sclerotized, and is delimited behind only by the variously modified mid-cephalic rim of the plate (as in *immunda* sp. nov., *pallitergata* sp. nov.). Both cephalic and caudal rims of the saucer may bear major teeth or denticles, the size of which is best judged when viewed laterally. In the *excisa* group, the mid-caudal region of the plate bears a stout median spine (*excisoides* sp. nov., *kamchatkana* sp. nov.).

The basistyle is sometimes simple but more often its caudal margin is produced into a conspicuous spine that may be either pale, tipped with black, or entirely blackened. Such a spine is found in the four commonest European species (*excisa* Schummel, *nervosa* Meigen, *rubripes* Schummel, and *scripta* Meigen) but is lacking in *sintenisi* Lackschewitz. The species of *Vestiplex* in eastern Siberia fall in the following groups based on this feature of the basistyle:

1. Basistyle unarmed; *arctica* Curtis, *kuwayamai* Alexander, *subcentralis* Alexander, *tchukchi* sp. nov., *transbaikalica* sp. nov.
2. Basistyle with an elongate acute spine; *excisoides* sp. nov., *immunda* sp. nov., *kamchatkana* sp. nov., *pallitergata* sp. nov.
3. Basistyle with spine expanded at tip to appear more or less bifid; *coquillettiana* Alexander.

The male of *Tipula jakut* Alexander is unknown. Whether the true *arctica* occurs in eastern Siberia is somewhat questionable to me, although it is definitely known from Taimyrland (reported in letter by Lackschewitz). The species falls in the group with unarmed basistyle and may be told by the dark body coloration, unusually marked nodulose antennæ of the male sex, and the simple structure of the inner dististyle of the male hypopygium.

TIPULA (VESTIPLEX) EXCISOIDES sp. nov. Plate 1, fig. 1; Plate 2, figs. 25, 26.

Allied to *excisa;* nasus short and stout, or lacking; antennæ (male) with the flagellar segments strongly incised, the first flagellar segment pale; terminal flagellar segment elongate; mesonotal præscutum gray, with four darker gray stripes that are narrowly bordered by brown; wings pale brown, variegated by darker brown and whitish areas; abdomen chiefly reddish brown, the outer segments darkened; male hypopygium with the tergal saucer bearing an acute median spine on caudal border.

Male.—Length, 16 to 17 millimeters; wing, 15 to 16; antenna, about 5.

Female.—Length, 25 millimeters; wing, 16; abdomen alone, 19.5.

Frontal prolongation of head yellowish brown, sparsely pruinose; nasus short to lacking; palpi brownish black. Antennæ (male) with the basal three segments yellow, the succeeding one or two weakly bicolorous, the remainder almost uniformly brownish black, the basal enlargement being a trifle darker than the remainder; flagellar segments very strongly incised; terminal segment elongate, exceeding one-third the length of the penultimate. In female, antennæ much shorter, chiefly yellow, only the outer segments darkened. Head gray.

Mesonotal præscutum light gray, with four slightly darker gray stripes that are narrowly bordered by dark brown; scutum light gray, the lobes variegated by darker gray; posterior sclerites of notum light gray. Pleura light gray; dorsopleural region buffy. Halteres pale, the knobs dark brown, their extreme tips pale. Legs with the coxæ gray; trochanters yellow; femora yellow, the tips narrowly and gradually infuscated; tibiæ yellowish brown, the tips darkened; tarsi passing into black. Wings (Plate 1, fig. 1) pale brown, the prearcular and costal regions more yellowish; stigma and smaller areas at origin of Rs and on anterior cord brown; whitish areas on disk, including the bases of the outer radial cells, cell 1st M_2, a conspicuous fenestrate area at two-thirds the length of cell M, and a common mark that includes the base of cell M and subbasal spots in cells Cu and 1st A; veins brown. Venation: R_3 sinuous; m a little shorter than the petiole of cell M_1; M_{3+4} subequal to or shorter than m.

Abdomen chiefly reddish brown, the outer segments darkened; tergites with a very narrow brown sublateral line, more conspicuous on basal segments, the actual borders narrowly pale; abdomen of female moderately long. Male hypopygium with the caudal portion of ninth tergite (Plate 2, fig. 25, 9*t*) appearing as a black polished saucer, much as in *excisa* but with the median caudal horn stout, pointed at apex, and unprovided with setæ; cephalic border of saucer, 9*t*, without, or with but few, raised points or denticles. In *excisa* (Plate 2, fig. 26), the median caudal horn of tergite, 9*t*, is slender, truncated at tip, the sides of the horn with erect black setulæ; cephalic border of saucer with a series of from six to eight elevated blackened points.

Habitat.—Eastern Siberia (Kamchatka).

Holotype, male, Ajan, 137° 30′ east longitude, 56° 40′ north latitude, July 18 to 31, 1912 (*Czerski*), No. 726. Allotype, female, Kamchatka River, 159° east longitude, 56° north latitude, July and August, 1914 (*Bjeloussov*, Hydrographic Expedition to Pacific), No. 558. Paratopotype, 1 male, 1903 (*Popoff*), No. 447. Paratypes, 4 males, with allotype, Nos. 552, 554, 555, 557; 1 male, Petropavlovsk, July 27, 1907 (*Smirnov*), No. 650; 1 male, Petropavlovsk, June 17, 1910 (*Skorikov*), No. 644; 1 male, mouth of Kichiga River, June 27, 1910 (*Skorikov*), No. 648.

The closest relative of the present fly is *Tipula* (*Vestiplex*) *excisa* Schummel, of Europe, which differs in slight structural and colorational details. In *excisa* the flagellum is entirely black, with the terminal flagellar segment small and thimble-like; male hypopygium with the median horn of tergal saucer truncated at apex, the sides with conspicuous, erect, black setulæ. A third member of this restricted group is *T.* (*V.*) *balioptera* Loew, of boreal North America, which differs in the bicolorous antennal flagellum and details of structure of the male hypopygium.[2]

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[2] Alexander, Mem. Cornell Univ. Agr. Exp. Sta. 25 (1919) 948, pl. 46, fig. 227 (wing); pl. 50, fig. 279 (ninth tergite); pl. 54, fig. 337 (lateral aspect of male hypopygium).

TIPULA (VESTIPLEX) KAMCHATKANA sp. nov. Plate 1, fig. 2; Plate 2, fig. 27.

Allied to *excisa;* general coloration of body black, heavily gray pruinose; antennæ (male) with flagellar segments strongly incised; entire antennæ black, excepting the reddish pedicel; præscutum gray, with four slightly darker stripes and a very conspicuous brownish black median præscutal vitta; tips of femora broadly blackened, most extensively so on forelegs; wing pattern very diffuse.

Male.—Length, 14 to 16 millimeters; wing, 14 to 15; antenna, 4.3 to 4.5.

Female.—Length, 12 to 14 millimeters; wing, 12 to 13.

Frontal prolongation of head black, heavily pruinose; nasus distinct; palpi black. Antennæ black, only the pedicel obscure reddish; scape pruinose; in cases the pedicel is black, like the remainder of organ; flagellar segments strongly incised; verticils short and powerful, shorter than the segments; terminal segment about two-fifths the penultimate. Head dark gray, with indications of a blackish median stripe.

Mesonotum gray, the præscutum with four poorly defined grayish brown stripes that are very narrowly bordered by brown, the latter sometimes obsolete, especially on the cephalic portions of the sclerite; a very distinct, dull brownish black, median, præscutal stripe; posterior sclerites of mesonotum blackish, gray pruinose. Pleura gray pruinose; dorsopleural region obscure buffy. Halteres infuscated, the knobs strongly so. Legs with the coxæ gray; trochanters yellow; femora obscure yellow basally, the tips broadly blackened, most extensively so on the forelegs, where nearly the outer three-fifths are darkened, on the posterior femora with more than the outer third blackened; tibiæ and tarsi brown, the latter passing into black. Wings (Plate 1, fig. 2) with a very pale brown tinge, the prearcular and costal regions brighter yellow; stigma pale brown, confluent with similar vague areas on anterior cord; ill-defined whitish areas beyond stigma, across cell 1st M_2 and near outer end of cell M; veins brown, brighter in the flavous areas. Venation: Cell M_1 variable, from about one-half longer than its petiole to twice as long as petiole.

Abdomen black, dark gray pruinose; lateral borders of tergites pale, the caudal margins very narrowly so. Male hypopygium much as in *excisoides;* tergal plate (Plate 2, fig. 27, 9*t*) relatively small, the lateral lobes broadly truncated; median-caudal spine stout; posterior border of saucer with about six blackened denticles. Basistyle and dististyles much as in *excisoides*.

Female generally as in the male; fully winged.

Habitat.—Eastern Siberia (Kamchatka).

Holotype, male, Alpine zone of the Shiveluch Range, 162° 30′ east longitude, 56° 40′ north latitude, June 25, 1909 (*Dershavin*), No. 399. Allotype, a broken female, Shiveluch Volcano, near Nischnekamchatsk, June 26, 1909 (*Schmidt*), No. 331. Paratopotypes, 3 males, Nos. 395, 397, 398; 1 broken female, No. 396. Paratypes, 1 male, Volcano Kluchevskoje, Kyrgurich, altitude 3,000 to 4,000 feet, June 12, 1909 (*Dershavin*), No. 393; 7 males and females, with the allotype, Nos. 327, 329–330, 332–335, inclusive; 1 male, Kluchevskoje Village, June 10, 1909 (*Dershavin*), No. 357; 1 male, Ust-Kamchatsk, near Nischnekamchatsk, July 17, 1909 (*Dershavin*), No. 348; 1 broken male, Alpine zone of Solocha River, Volcano Kluchevskoje, June 13, 1909 (*Dershavin*), No. 403; 1 female, Krutenkaja River, June 22, 1909 (*Koslovsky*), No. 422. These materials were collected on the Rjabushinsky Brothers Expedition, 1909.

Tipula (*Vestiplex*) *kamchatkana* is allied to *excisa* Schummel, *excisoides* sp. nov., and *balioptera* Loew. It is well distinguished by the black antennæ, with only the pedicel obscure reddish, the conspicuous median præscutal stripe, the extensively blackened fore femora, and other features. The general coloration of the entire body is black, heavily pruinose with gray.

TIPULA (VESTIPLEX) PALLITERGATA sp. nov. Plate 1, fig. 3; Plate 2, fig. 28.

General coloration light gray, the præscutum with four darker gray stripes that are conspicuously bordered by brown; antennæ (male) elongate, nearly one-half the length of body; femora obscure yellow, the tips blackened, more extensively so on forelegs; wings with the pattern pale and diffuse, chiefly pale brown and white; male hypopygium with the tergal plate light yellow, including the saucerlike posterior portion; at near center of disk a small transverse elevation bearing two blackened points; spine of basistyle straight, pale, the narrow acute tip blackened.

Male.—Length, 14 to 15 millimeters; wing, 15 to 15.5; antenna, 6.5 to 7.5.

Frontal prolongation of head gray; nasus long and conspicuous; palpi black. Antennæ (male) unusually long for a member of this subgenus, only a little less than one-half the length of the body; scape dark, pruinose; pedicel obscure yellow; succeeding segments very weakly bicolorous, dark brown, the basal enlargements black; segments beyond the fifth passing into uniform black; in the paratype the antennæ are much more extensively bicolorous; flagellar segments strongly incised; verticils shorter than the segments; terminal segment about one-third the length of penultimate. Head gray, the vertex with a broad, conspicuous brown line.

Mesonotal præscutum light gray, with four darker gray stripes that are conspicuously bordered by brown, especially on their cephalic portions; intermediate stripes broad in front, narrowed behind, contiguous at ends but widely separated at midlength, the brown margins suffusing the outer ends of stripes; lateral stripes without dark markings along most of their mesal edge; posterior sclerites of notum light gray, the scutal lobes variegated with dark gray, of which the more cephalic area is narrowly ringed with brown; scutellum with a more or less distinct median brown line. Pleura gray; dorsopleural region buffy. Halteres long, pale yellow, the knobs dark brown. Legs with the coxæ pale gray; trochanters obscure yellow; femora obscure yellow, the tips blackened, more extensively so on forelegs where approximately the outer third or more is darkened, very narrowly blackened on the other legs, tibiæ brown, the tips passing into black; tarsi black. Wings (Plate 1, fig. 3) with the ground color very pale brown; prearcular and costal regions light yellow; very extensive whitish areas over most of wing disk, greatly restricting the ground color; slightly darker brown clouds at origin of Rs and on anterior cord; veins brown, yellow in the flavous areas. Venation: M_{3+4} variable, being longer or shorter than the petiole of cell M_1.

Abdominal tergites reddish brown, narrowly trivittate with brown, the median stripe broader and nearly continuous; sublateral stripes very narrowly interrupted; lateral margins gray; outer segments brown, heavily pruinose, the caudal margins narrowly pale. Male hypopygium brownish yellow, the tergal plate pale, not polished black as in other regional members of the subgenus. Hypopygium with the tergal plate (Plate 2, fig. 28, 9*t*) pale yellow, including the outer saucer; caudal margin with a broad U-shaped notch, at the base of which is a tiny rounded notch; cephalic portion of saucer with an elevated, blackened transverse ridge that is set with a blackened point on either side of midline. Basistyle, *b*, with an elongate straight spine, pale except for the short, gently curved apex. Outer dististyle, *od*, pale, slightly flattened. Inner dististyle, *id*, broad, bifid at apex, the outer spine acute.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Vladivostok, May 29, 1927 (*Stackelberg*), No. 229. Paratype, male, Maiche region, near Shkotovo, June 4, 1927 (*Sokolov*), No. 579.

The pale yellow ninth tergite of the male hypopygium readily separates this fly from all other regional allied forms. In this respect it suggests the eastern Nearctic *Tipula* (*Vestiplex*) *caroliniana* Alexander and *T.* (*V.*) *longiventris* Loew, which are otherwise quite different flies. The antennæ of the male of the present fly are of an unusual length for a member of this subgenus.

TIPULA (VESTIPLEX) IMMUNDA sp. nov. Plate 1, fig. 4; Plate 2, fig. 29.

General coloration light gray, the præscutum with four slightly darker gray stripes that are narrowly bordered by brown; antennæ (male) relatively short; wings with bases of cells R and M narrowly darkened; male hypopygium with the tergal plate pale, the cephalic rim appearing as an elevated quadrate plate, its margin narrowly blackened; basistyle produced into a strong pale spine.

Male.—Length, about 15 millimeters; wing, 16.5; antenna, about 3.

Frontal prolongation of head brownish gray; nasus stout; palpi black. Antennæ (male) unusually short for a member of this subgenus; basal three segments yellow; succeeding segments bicolorous, the basal enlargement darker than the apices; outer segments more uniformly darkened; flagellar segments weakly incised; verticils subequal to or slightly longer than the segments; terminal segment about one-third the penultimate. Head gray; a vague capillary blackish line on vertex; setigerous punctures black, conspicuous.

Mesonotal præscutum light gray, with four slightly darker gray stripes that are narrowly but conspicuously bordered by brown; intermediate stripes a little bowed beyond midlength to expose a linear strip of the ground; scutum light gray, each lobe with two darker gray areas that are very insensibly bordered by brownish, this being especially apparent along the cephalic borders; posterior sclerites of mesonotum light gray, the mediotergite with a narrow median dusky vitta. Pleura with the mesepisternum gray, the posterior sclerites more whitish gray. Halteres pale, the knobs infuscated. Legs with the coxæ light gray; trochanters yellow; femora obscure yellow, the tips narrowly blackened; tibiæ brownish yellow, the tips narrowly darkened; tarsi passing into black. Wings (Plate 1, fig. 4) with the ground color brown, variegated by darker brown and whitish, the pattern more diffuse than usual; a dark post-arcular area in bases of cells R and M; veins brown. Macrotrichia relatively abundant on veins beyond cord; R_{1+2} glabrous on outer half; vein 1st A entirely without trichia; vein 2d A with numerous trichia on more than distal half. Venation: Cell 1st M_2 elongate, with m-cu just before midlength of lower face.

Abdominal tergites dark reddish yellow, with a narrow, interrupted blackish median stripe; sublateral dark stripes almost obsolete; basal sternites yellow; outer abdominal segments more uniformly darkened. Male hypopygium (Plate 2, fig. 29) with the tergal plate, 9*t*, very different from the other regional members of the subgenus. The main body of the tergal saucer is pale, with the caudal margin broadly emarginate, the cephalic border appearing as an elevated quadrate plate whose margin is narrowly blackened; in a position of rest, the pale portion of the saucer is deflected ventrad so the elevated cephalic plate forms what appears to be the extreme caudal edge of the tergite, in this case being directed caudad instead of the normal position of cephalodorsad; caudal lobes of tergite pale with long pale setæ. Basistyle, *b*, with a strong spine, pale in color, the extreme tip acute and blackened. Outer dististyle, *od*, flattened. Inner dististyle, *id*, broad, the outer margin at near two-thirds the length with a sharp spine.

Habitat.—Eastern Siberia (Saghalien).

Holotype, male, Nodeskda Bay, July 9, 1908 (*Soldatov*), No. 682.

In its pale ninth tergite of the male hypopygium, with no blackened armature excepting a glabrous plate at cephalic end of saucer, the present fly is closest to *Tipula* (*Vestiplex*) *palliergata* sp. nov., differing especially in the short antennæ of the male and in the details of structure of the hypopygium. The nature of the tergal saucer is different from that of any other Old World species known to me.

TIPULA (VESTIPLEX) COQUILLETTIANA Alexander.

Tipula coquillettiana ALEXANDER, Philip. Journ. Sci. 24 (1924) 605–606; Encycl. Entomolog., Diptera 2 (1925) 91–92, figs. 6–8 (details of male hypopygium).

The types, two males, were collected at Odasam, southern Saghalien, in August by Prof. Teiso Esaki. A further male was later taken in Hokkaido, Japan, in August, by Mr. Tamanuki.

A further series of specimens from eastern Siberia seem surely referable to this species, despite certain slight differences in coloration and structure. The subapterous female is described below as allotype.

Allotype.—Female, length, about 30 millimeters; wing, 5; abdomen alone, 24.

Wings greatly reduced, stenopterous, appearing almost uniformly infuscated. Basal four or five flagellar segments pale, the succeeding segments bicolorous, the outer segments more uniformly darkened. Præscutal stripes poorly indicated against the gray ground color. Abdomen long, chiefly gray, the tergites obscure reddish on either side of midline. Ovipositor with tergal shield and cerci polished brownish black. Hypovalvæ terminating in slender, hairlike points.

Allotype, female, Nikolajevsk, Amur River, July 21, 1915 (*Chernavin*), No. 701.

Other records: A female, Chhil region, Amur River, Ussuri, July 28, 1908 (*Soldatov*), No. 660; a female, Selenyi border, Ussuri, 600 kilometers from Habarovsk, 1908 (*Soldatov*), No. 681; males and females, Osernaja, mouth of the Amur, June 10 to 13, 1915 (*Chernavin*), Nos. 705, 708, 712; a female, Okonen River, Amur, June 21 to 23, 1914 (*Dorogostaiski*), No. 599; a female, with the allotype, No. 704.

It is possible that more than a single species is confused in the above series, since the antennal flagella vary in color from brownish black to bicolorous, but in the absence of sufficient males, I am unable to separate the flies.

TIPULA (VESTIPLEX) KUWAYAMAI Alexander.

Tipula kuwayamai ALEXANDER, Ann. Ent. Soc. Am. 14 (1921) 130–131; Encycl. Entomolog., Diptera 2 (1925) 93.

Described from Sapporo, Hokkaido, Japan; collected in June by Prof. Satoru Kuwayama. Later (Alexander, 1925) reported from the Ussuri. A considerable series of additional specimens are available.

Golden Horn, Vladivostok, May 25 to June 1, 1911 (*Rydzevski and Kuznetzov*), Nos. 427 to 429; Sedanka, near Vladivostok, June 20, 1927 (*Stackelberg*), No. 248; Okeanskaja station, June 25, 1926 (*Mordvilko*), No. 614; Tigrovaja, Suchan district, June 3 and 4, 1927 (*Stackelberg*), No. 93; Vinogradovka, May 30 to June 2, 1929 (*Djakonov and Filipjev*), Nos. 548, 549; Maiche region, near Shkotovo, June 7, 1927 (*Sokolov*), Nos. 570, 573; Spassk, June 4, 1928 (*Obolenskij*), No. 589; Kamen-Rybolov, Lake Chanka, May 24 and 25, 1908 (*Czerski*), No. 301; Seja River, Amur Province, June 27 to 29 (*Rittig*), No. 639; Saghalien Island, August 9 to 22, 1906 (*Smirnov*), No. 649; Pilva, Saghalien, June 27, 1910 (*Derbeck*), No. 319.

Many of the specimens, especially the males, average somewhat larger than the types (male, length, 19 to 20 millimeters; wing, 21 to 23; female, length, 28 to 31 millimeters; wing, 24 to 25). In some specimens, all four præscutal stripes are clear light gray, bordered by brown; in certain other cases, the intermediate stripes are more suffused with brown, especially on their posterior portions, the broad lateral stripes remaining clear light gray, contrasting strongly with the intermediate pair. In some other specimens, the interspaces likewise become suffused with light brown.

TIPULA (VESTIPLEX) TRANSBAIKALICA sp. nov. Plate 1, fig. 5; Plate 2, fig. 30.

General coloration of head and thorax gray, the præscutal stripes scarcely differentiated from the ground; antennæ with basal flagellar segments bicolorous; knobs of halteres yellow; wings pale brown, with a weak darker brown and white pattern; abdomen obscure yellow, the subterminal segments darker; male hypopygium with a conspicuous, polished, black tergal saucer, the caudal rim notched medially, the lateral lobes obliquely truncated and coarsely toothed; no caudal production of basistyle; outer dististyle flattened-oval; inner dististyle unusually short, bifid at apex.

Male.—Length, about 18 millimeters; wing, 19; antenna, about 3.8.

Frontal prolongation of head reddish brown; nasus short and stout; palpi obscure brownish yellow, the outer segment darkened at outer end. Antennæ with scape and pedicel obscure yellow; basal flagellar segments bicolorous, the basal enlargement dark brown, the stem yellow; fifth and succeeding flagellar segments more uniformly darkened; terminal segment slightly exceeding one-half the length of the penultimate. Head dark gray.

Pronotum brownish gray. Mesonotal præscutum almost uniformly dark gray, the usual stripes scarcely differentiated from the ground; posterior sclerites of mesonotum gray, the scutellum more brownish. Pleura extensively brownish gray, the posterior sclerites, especially the pleurotergite, more yellowish; dorsopleural membrane buffy. Halteres pale, the knobs light yellow. Legs with the coxæ light gray pruinose, the apices paling to yellowish; trochanters yellow; femora yellow, the tips narrowly dark brown; tibiæ reddish brown, the tips darkened; tarsi brownish black. Wings (Plate 1, fig. 5) with the ground color very pale brownish, the prearcular and costal regions light yellow; stigma brown; much reduced brown clouds at origin of Rs and on anterior cord; whitish hyaline areas as follows: An incomplete cross band beyond cord, occupying parts of cells Sc_2, R_2, and R_3, separated from an obliterative area across cell 1st M_2 by a darkened seam along vein M_{1+2}; an ill-defined white area in cell M beneath origin of Rs; veins brown, obliterative areas extensive. Venation: R_{1+2} entire, the distal half glabrous; petiole of cell M_1 about twice the length of m; M_{3+4} about three-fourths the basal section of M_3; m-cu on M_4 just beyond base.

Abdomen obscure yellow basally, the mid-line of basal tergites with a narrow to scarcely evident broken brown line; subterminal abdominal segments darkened. Male hypopygium (Plate 2, fig. 30) with the basistyle large, chiefly separated from the sternite by extensive dorsal and ventral sutures, the intermediate fourth or thereabouts fused. Ninth tergite, *9t*, with the caudal portion a conspicuous blackened saucer, relatively small, the caudal margin with a U-shaped median notch, the lobes obliquely truncated, with several coarse teeth that alternate with long setæ; cephalic margin of saucer elevated, each half with two teeth, the lateral pair larger. Basistyle without armature. Outer dististyle, *od*, a flattened oval blade, with numerous pale setæ. Inner dististyle, *id*, unusually short, less than the outer style, bifid at apex.

Habitat.—Eastern Siberia (Transbaikal).

Holotype, male, Borochojeva (ex Staudinger-Bang Haas); type in author's collection.

Among the regional species, *Tipula* (*Vestiplex*) *transbaikalica* is most nearly allied to flies such as *T.* (*V.*), *subcentralis* Alexander, differing conspicuously in the structure of the male hypopygium. The fly is even more closely related to *T.* (*V.*) *sintenisi* Lackschewitz, of northern Europe, which differs in the black palpi, dusky knobs of halteres, brown-margined præscutal stripes, and other features; the details of the male hypopygium are very similar in the two species.

TIPULA (VESTIPLEX) SUBCENTRALIS Alexander. Plate 2, fig. 31.

Tipula subcentralis ALEXANDER, Journ. New York Ent. Soc. 26 (1918) 73–74; Encycl. Entomolog., Diptera 2 (1925) 92–93, figs. 9–11 (details of male hypopygium).

The type, and previously only known specimen, is a unique male that was collected in Kamchatka by Leonhard Stejneger.

Two additional specimens present the following data: A male, in teneral condition, Kamchatka River, Kamchatka, 159° east longitude, 56° north latitude, 1898 (*Gondatti*), No. 591. A second male in good condition, valley of Bystraja River, Kamchatka, July 15, 1908 (*Protopov*), No. 419.

The male hypopygium has the tergal saucer with caudal margin subtransverse to very feebly notched, the margin with microscopic denticles, of which a submedian pair is slightly larger; cephalic border of saucer with scanty denticles. Basistyle unarmed. Outer dististyle (Plate 2, fig. 31, *od*) a narrowly flattened pale lobe. Inner dististyle, *id*, terminating in a simple, obtusely rounded apex, with a carina back from tip. The simple inner dististyle is characteristic of the species.

TIPULA (VESTIPLEX) TCHUKCHI sp. nov. Plate 1, fig. 6; Plate 2, figs. 32, 33.

Size small (wing about 12 to 13 millimeters); mesonotum black, with four darker gray stripes; antennæ (male) with flagellar segments strongly incised; basal flagellar segments bicolorous; male hypopygium with the tergal saucer very large, heavily blackened, extended cephalad so as to overlie the eighth tergite, the cephalic border elevated; basistyle unarmed.

Male.—Length, about 11 to 12 millimeters; wing, 12 to 13.2.

Female.—Length, about 16 millimeters; wing, 12.

Frontal prolongation of head dark gray; nasus short and blunt; palpi brownish black. Antennæ (male) of moderate length; scape brownish yellow; pedicel and first flagellar segment obscure yellow; succeeding flagellar segments weakly bicolorous, the basal enlargement black, the outer portion obscure yellow; outer segments more uniformly blackened; flagellar segments rather strongly incised, only a very little less so than in the *excisa* group. Head gray, with a capillary black median vitta extending the whole length of the sclerite.

Mesonotal præscutum black, very thinly pruinose with dark leaden gray to produce four scarcely apparent stripes, the interspaces darker; the paratypes have the pruinosity heavier to produce four dull gray stripes that are vaguely bordered by brown; posterior sclerites of notum gray. Pleura light gray, the dorsopleural region more buffy. Halteres pale yellow, the knobs weakly darkened. Legs with the coxæ light gray; trochanters yellow; remainder of legs broken. Wings (Plate 1, fig. 6) with the ground color very pale brown, variegated by whitish areas; prearcular and costal regions light yellow; stigma oval, dark brown; the white areas include a nearly complete fascia beyond cord, a large conspicuous spot in outer half of cell M, the bases of cells Cu and 1st A, with other less evident brightenings; veins brown, paler in the white areas. Venation: M_{3+4} subequal to or shorter than basal section of M_3.

Abdomen with basal tergite brownish gray; succeeding tergites yellow, with a very narrow median brown stripe that is narrowly interrupted at caudal margin of the segments; lateral borders of tergites rather narrowly bordered by buffy, delimited internally by a delicate dusky line; outer segments, including hypopygium, uniformly blackened; basal sternites yellow. In the female, the tergites show three broader and more continuous brown stripes that continue caudad to the shield of the ovipositor. Male hypopygium (Plate 2, fig. 32) with the tergal saucer (Plate 2, fig. 33, 9*t*) unusually large and conspicuous, heavily blackened, when viewed from above covering the whole dorsal surface of tergite; posterior border of saucer free and conspicuously elevated, in a position of rest extending back over the caudal border of the eighth tergite, quite concealing the mid-cephalic region of the ninth tergite; viewed laterally, the saucer bears about four spinous points on either side, the cephalic and caudal ones larger; lobes of caudal border of tergite broadly truncated and provided with microscopic blackened denticles. Basistyle small, entirely unarmed. Outer dististyle, *od*, moderately flattened, dusky in color. Inner dististyle, *id*, flattened, the apex only shallowly bidentate. Ovipositor with the dorsal teeth of cerci subobsolete, the ventral row conspicuous.

Habitat.—Eastern Siberia (Anadyr Region, Kamchatka).

Holotype, male, Markovo, Chuckchiland, Anadyr Gulf, 170° east longitude, 65° north latitude, July 6, 1896 (*Gondatti*), No. 586. Allotopotype, female, No. 585. Paratypes, 2 males, mouth of Kichiga River, Kamchatka, June 27, 1910 (*Skorikov*), Nos. 646, 647.

The specific name is that of an aboriginal tribe inhabiting extreme northeastern Asia. In the unarmed basistyle, the present fly groups with species such as *kuwayamai* Alexander, *sub-*

centralis Alexander, and *transbaikalica* sp. nov., differing from all in the small size, general coloration, and, especially, the very extensive tergal saucer of the male hypopygium.

Subgenus ARCTOTIPULA subgen. nov.

Nasus in most cases relatively short. Body conspicuously hairy, with setæ, on all coxæ and usually on sternopleurite. Tibial spur formula 1–2–2; claws simple. Squama naked; veins beyond cord without macrotrichia or with these much reduced in size and number, most persistent as a loose series on R_{4+5}; in some species, as *gavronskii,* the trichia more abundant. Venation: R_{1+2} entire; cell M_1 usually short-petiolate to sessile, longer in certain species, as *alascænsis;* m-cu lying proximad of to about opposite r-m. Abdomen often depressed. Male hypopygium of simple structure, the tergite separate from sternite. In female, the terminal abdominal segments abruptly narrowed, the ovipositor very small; cerci moderately elongate and only weakly sclerotized, the margins smooth; hypovalvæ small and compressed.

Type of subgenus.—Tipula besselsi Osten Sacken (Arctic America).

Other included species are *T. salicetorum* Siebke (equals *T. nigricornis* Zetterstedt, preoccupied); *T. zetterstedti* Strobl, of northern Europe; *T. alascænsis* Alexander, *T. besselsoides* Alexander, and *T. piliceps* Alexander, of Arctic North America; and four species from eastern Asia, defined as new at this time, *T. gavronskii, T. hirtitergata, T. popoffi,* and *T. tundrensis.*

The chief features of subgeneric importance lie in the unusually glabrous wing veins and the peculiar structure of the ovipositor. As in some other subgeneric groups of *Tipula,* the male sex is more difficult of definition than is the female. The outer medial, cubital, and anal veins either entirely lack macrotrichia or these are greatly reduced. The abruptly narrowed genital segment of the female of most species, with small weak cerci, are likewise distinctive. *Tipula tundrensis* differs from the other included species in having a more glabrous body, the terminal segments of female abdomen not conspicuously narrowed, and the valves of the ovipositor approaching the type found in *Vestiplex,* though with smooth-margined cerci. The species further shows the caudal margin of the eighth sternite of the male hypopygium to be armed with setæ and hair pencils, characters that again are foreign to both *Arctotipula* and

Vestiplex. Riedel[3] records *besselsi* Osten Sacken from the Polar Ural region, but I must regard this identification as being very doubtful.

TIPULA (ARCTOTIPULA) HIRTITERGATA sp. nov. Plate 1, fig. 7; Plate 3, fig. 34.

General coloration brownish gray, the præscutum with four brown stripes; wings grayish subhyaline, stigma brown; no veins with obliterative sections; cell M_1 petiolate; abdomen obscure yellow, the tergites with a median brown longitudinal stripe that is narrowly interrupted at the caudal portion of the segments; ninth tergite of male hypopygium with very abundant black setæ that cover the entire outer portion of disk, the caudal margin with a deep U-shaped notch.

Male.—Length, about 16 millimeters; wing, 17; antenna, about 4.

Frontal prolongation of head relatively short and stout, buffy brown; nasus long and slender; palpi light brown. Antennæ with scape and pedicel brownish yellow; flagellum dark brown; flagellar segments relatively short, feebly incised, with basal verticils only, the longest of these subequal to segment; terminal segment thimble-shaped. Head gray; eyes relatively small; genæ prominent.

Mesonotal præscutum brownish gray, with four brown stripes, the intermediate pair separated only by a capillary line of the ground; lateral margins of præscutum, and especially the humeral regions, clearer gray; interspaces with appressed white setæ; scutum brownish gray, the lobes with slightly darker brown stripes; scutellum pale brown, mediotergite gray; a vague capillary median brown vitta extends from the præscutum to abdomen. Pleura light gray; dorsopleural membrane more buffy. Halteres buffy yellow throughout. Legs with the coxæ light gray, with conspicuous white setæ; trochanters yellow; femora obscure yellow, the tips weakly darkened; tibiæ and tarsi more infuscated. Wings (Plate 1, fig. 7) grayish subhyaline; stigma brown; veins pale brown, without obliterative areas. Macrotrichia relatively abundant but small, on veins beyond cord including an almost complete series on R_3, R_{2+3}, outer section of R_{4+5}, and a weak series of about a score of trichia on M_1; a few trichia near outer end of vein M; other trichia on Cu_1 on either side of level of m-cu; a series on distal third of 2d A; other veins behind R_1 chiefly destitute of trichia. Venation:

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[3] Mem. Acad. Sci. Russ. VIII 28, No. 8 (1919) 8.

R_{1+2} entire; petiole of cell M_1 about one-half m; M_{3+4} short, about one-third m; m-cu on M_4 shortly beyond origin.

Abdomen depressed, obscure yellow, the tergites with a conspicuous median longitudinal stripe that is narrowly interrupted at caudal margin of each segment, the areas of the individual segments being narrowed to a point behind; lateral borders of tergites paling to whitish; sternites uniformly yellowish white; pleural membrane darkened. Male hypopygium of unusually simple structure; tergite separate from sternite; basistyle and sternite fused. Ninth tergite (Plate 3, fig. 34, 9*t*) with a very deep U-shaped median notch, the lateral lobes relatively slender, grading to the lateral shoulders; outer half of tergite darkened but not heavily sclerotized, the surface of this portion with abundant coarse black setæ, those of the sides longer and more whitish; posterior half of tergite with sparse setæ; lobes of tergite fringed with delicate pale setulæ. Outer dististyle, *od,* broadly flattened, entirely pale. Inner dististyle, *id,* with a conspicuous, slightly curved black spine on outer margin at near two-thirds the length, the apical portion leaflike; a small group of peglike spines in axis of outer spine. Ninth sternite without lobes. Eighth sternite unarmed.

Habitat.—Eastern Siberia (Amur).

Holotype, male, Dulysmar River, June 5, 1914 (*Dorogostaiski*), No. 601.

Tipula (*Arctotipula*) *hirtitergata* is quite distinct from the other regional species of the subgenus in the petiolate cell M_1 and uniform coloration of wings, the latter without evident obliterative areas.

TIPULA (ARCTOTIPULA) GAVRONSKII sp. nov. Plate 1, fig. 8; Plate 3, fig. 35.

General coloration gray, the præscutum with four darker stripes, the intermediate pair pale, narrowly margined with blackish, the lateral stripes solidly darkened; antennæ with the seven basal segments yellow; wings with a strong brown tinge, only slightly variegated by darker and pale areas; cell M_1 sessile; numerous macrotrichia on veins M_1 and M_2; abdomen depressed, obscure yellow; both the tergites and sternites with an interrupted brownish black median stripe; ovipositor abruptly narrowed; cerci weak and pale.

Female.—Length, about 17 millimeters; wing, 17.

Frontal prolongation of head relatively short and stout, yellowish brown, more pruinose above; nasus powerful; palpi brown. Antennæ with the basal seven segments yellow, the smaller outer segments darker; basal enlargements of segments scarcely developed; verticils exceeding the segments; terminal segment nearly as long as penultimate. Head gray, with a conspicuous dusky median line.

Mesothorax massive. Mesonotum gray, the præscutum with four darker stripes, the intermediate pair dark gray, narrowly bordered by blackish, the lateral borders beginning at about one-fourth the length of the sclerite, narrowed behind, ending just before the suture; median dark vitta, representing the common internal border of the intermediate stripes extending the entire length of præscutum; lateral stripes relatively narrow but uniformly blackened; humeral region and lateral border of præscutum before suture infuscated; scutum gray, each lobe variegated with blackish areas; scutellum dark gray, brownish black medially, the parascutella pale; mediotergite gray, with a conspicuous dark median line. Pleura buffy, variegated with gray on anepisternum, sternopleurite, and meron; sternopleurite glabrous. Halteres yellow, the knobs dark brown. Legs with the coxæ brownish gray; trochanters yellow; femora yellow, the tips narrowly but very conspicuously blackened; tibiæ yellow, the tips blackened, the degree approximately twice the femoral darkening; tarsi brown; tibial spurs sinuous; claws (female) simple. Wings (Plate 1, fig. 8) with a strong brown tinge, the stigma darker brown; obliterative areas before stigma and across cell 1st M_2; veins brown. Macrotrichia numerous on veins beyond cord, including both M_1 and M_2, becoming more sparse on M_3. Venation: R_{1+2} entire; cell M_1 sessile; m-cu at fork of M_{3+4}, opposite r-m.

Abdomen depressed; basal six tergites obscure yellow, with a very conspicuous, nearly continuous, brownish black, median stripe, this very narrowly interrupted at the extreme caudal margins of segments; terminal segments uniformly dark brown; much paler brown sublateral stripes on tergites; lateral borders pale; sternites yellow, segments two to five, inclusive, with a clearly defined broken black median stripe. Abdominal segments (Plate 3, fig. 35, *o*) beyond the eighth abruptly narrowed; cerci pale, weakly developed, wider at base, narrowed beyond mid-length; basal portion of cerci with pale delicate setulæ.

Habitat.—Eastern Siberia (Ussuri).

Holotype, female, Vladivostok, August 10, 1903 (*Gavronsky*), No. 499.

Tipula (*Arctotipula*) *gavronskii* is named in honor of the collector, who has collected numerous Tipulidæ near Vladivostok. The species is readily told from the other members of the subgenus by the strongly infumed wings, with an unusual number of macrotrichia on the outer medial veins and with cell M_1 sessile. The most similar member of the subgenus is *T.* (*A.*) *popoffi* sp. nov. Attention should be called to the superficially similar *Tipula moiwana* (Matsumura), which is associated with the present fly in collections, but is a typical member of the genus, with normally developed cerci.

TIPULA (ARCTOTIPULA) POPOFFI sp. nov. Plate 1, fig. 9; Plate 3, fig. 36.

Mesonotal præscutum light gray, with four darker gray stripes; antennal flagellum black; femora yellow, the tips narrowly infuscated; wings yellowish gray; stigma brown; wing disk scarcely variegated; macrotrichia of veins beyond cord almost lacking; cell M_1 sessile or nearly so; abdominal tergites yellow, trilineate with dark brown, the lateral borders whitish; sternites clear light gray, the caudal borders yellow.

Female.—Length, about 17 millimeters; wing, 18.5; antenna, about 3.3.

Frontal prolongation of head gray, with long yellow setæ; nasus very short and broad; palpi black. Antennæ with the scape and pedicel brownish yellow; flagellum black; verticils of flagellum exceeding the segments. Head brownish gray, somewhat clearer gray on front and along orbits.

Pronotum light gray, darker medially. Mesothorax broad and massive, the præscutum light gray with four darker brownish gray stripes, the intermediate pair only narrowly separated; interspaces with short yellow setæ; posterior sclerites of thorax gray, the scutellum and mediotergite with indications of a darker median line. Pleura gray, the dorsopleural region buffy; mesopleura glabrous. Halteres yellow, the knobs infuscated. Legs with the coxæ gray, with conspicuous white setæ; trochanters yellow; femora yellow, the tips narrowly infuscated, the amount subequal on all legs; tibiæ brownish yellow; tarsi pale brown. Wings (Plate 1, fig. 9) with a yellowish gray tinge; stigma brown; obliterative areas restricted; vague cream-colored brightenings before and beyond stigma; veins brown. Macrotrichia of veins beyond cord very sparse to virtually lacking, those on vein R_{4+5} being restricted to a series of about a dozen and very small. Venation: R_{1+2} nearly straight, diverging strongly from R_3; cell M_1 very short-petiolate to sessile; M_{3+4} about one-third the basal section of M_3.

Abdomen stout, the tergites conspicuously trilineate with dark brown, the narrower median stripe slightly interrupted at caudal margins of segments, the sublateral stripes broader and more nearly continuous; lateral borders of tergites broadly whitish; remainder of tergites, including the interspaces and caudal borders of segments bright yellow; eighth and succeeding segments darkened; sternites uniformly clear light gray, only the narrow posterior borders pale yellow. Ovipositor (Plate 3, fig. 36, *o*) with the segments suddenly narrowed, as normal for the subgenus; cerci pale, outer margins a little dilated before tips.

Habitat.—Eastern Siberia (Jakutsk).

Holotype, female, between Ajan and Nelkan, Tongi River Valley, 137° 30′ east longitude, 56° 40′ north latitude, June 9 to 15, 1903 (*Popoff*), No. 441.

The nearest ally is *Tipula* (*Arctotipula*) *gavronskii* sp. nov., which is readily told by the strongly darkened wings, different thoracic coloration, dark median stripe on abdominal sternites, abundant macrotrichia on outer veins of wings, and other characters.

TIPULA (ARCTOTIPULA) TUNDRENSIS sp. nov. Plate 1, fig. 10; Plate 3, figs. 37, 38.

General coloration gray, the præscutum with three slightly darker gray stripes; antennæ black, relatively short; wings brown, marmorate with whitish and sparse darker brown areas; abdomen dark gray throughout; male hypopygium with the caudal margin of eighth sternite provided with hair pencils; ovipositor not conspicuously narrowed, the cerci relatively wide, with smooth margins.

Male.—Length, about 14 millimeters; wing, 15; antenna, about 3.8.

Female.—Length, about 17 millimeters; wing, 14.5.

Frontal prolongation of head gray; nasus stout; palpi black. Antennæ black, the scape pruinose; pedicel sometimes more or less reddish at tips; flagellar segments relatively short but still longer than the verticils; terminal segment thimble-shaped. Head gray.

Mesonotum gray, the præscutum with three slightly darker gray stripes that are poorly indicated. Pleura gray, the dorsopleural membrane buffy. Halteres yellow, the knobs infuscated. Legs with the coxæ pruinose; trochanters black; femora deep reddish brown, the tips blackened; tibiæ dark brown; tarsi black. Wings (Plate 1, fig. 10) brown, marmorate with whitish and sparse darker brown areas, the most evident of the latter being the stigma; restricted paler brown areas at origin of Rs and on anterior cord; the whitish areas include a post-stigmal fascia extending from C to cell R_5; a prestigmal brightening in cell R_1; a large spot near outer end of cell M, extending caudad into cell Cu; other whitish areas nearer wing base, including an arcuate line from base of cell M, through cells Cu and 1st A, to outer end of latter cell; veins brown. Macrotrichia of veins beyond cord restricted, being limited to a series of about a dozen on outer third of vein R_{4+5}, with very sparse scattered trichia on vein R_3, outer ends of M_1, M_2, and M_3, and a short series at midlength of distal section of Cu_1. Venation: R_{1+2} entire; cell 1st M_2 long, its inner end pointed; M_{3+4} about one-half the elongate basal section of M_3; petiole of cell M_1 a little longer than m.

Abdomen dark gray throughout; tergites with basal transverse impressed punctures. Male hypopygium (Plate 3, fig. 37) with the tergite separated from sternite; basistyle, *b*, relatively large, entirely distinct from sternite. Ninth tergite (Plate 3, fig. 38, 9*t*) with a broad V-shaped median notch, the sublateral lobes low and obtuse; on ventral face of tergite a further extension of the plate, apparently homologous with the tergal saucer of *Vestiplex* but confined to ventral surface of tergite; dorsal surface of tergite with very tiny setigerous punctures. A fingerlike appressed lobe, directed mesad and ventrad, lies at caudal margin of basistyle and ninth sternite. Eighth sternite (Plate 3, fig. 37, 8*s*) with caudal margin conspicuously armed, the median portion deeply emarginate, membranous, with a transverse row of long yellow setæ, each lateral angle with a pencil of still longer setæ, the pencil so dense and abundant as to appear almost like a spine. Penis unusually stout and relatively short; ædeagus, *a*, broad-based. Terminal segments of abdomen glabrous or with very small setæ only. Ovipositor with the cerci (Plate 3, fig. 38) unusually widened, somewhat as in *Vestiplex*, but the margins smooth; hypovalvæ short, about one-third the length of the cerci.

Habitat.—Eastern Siberia (Kamchatka).

Holotype, male, Volcano Kluchevskoi, Kyrgurich, altitude 3,000 to 4,000 feet, June 12, 1909 (*Dershavin*), No. 394. Allotype, female, Kljuchevskoje Village, altitude 3,000 feet, July 4, 1909 (*Dershavin*), No. 360. Paratypes, 1 female, with allotype, June 10, 1909, No. 355; 1 female, Petropavlovsk, June 1, 1908 (*Dershavin*), No. 367.

The present fly bears a superficial resemblance to *Tipula* (*Vestiplex*) *kamchatkana* sp. nov., with which it was associated in collections. It is a very different fly and seems to be more correctly placed in *Arctotipula*, the margins of the cerci being smooth.

TIPULA (LUNATIPULA) POLYPOGON sp. nov. Plate 1, fig. 11; Plate 3, figs. 39, 40.

General coloration grayish yellow, the median præscutal stripe a little darker, bordered laterally by brown; antennæ (male) relatively short, flagellum dark brown; wings yellowish gray, unmarked except for stigma; cell 1st M_2 relatively small; outer abdominal segments blackened; male hypopygium large, unusually complicated by tufts and brushes of yellow setæ, especially on eighth sternite.

Male.—Length, about 15 millimeters; wing, 18; antenna, 4.5.

Female.—Length, about 20 millimeters; wing, 18.

Frontal prolongation moderately long, yellow; nasus short and stout; basal segment of palpus yellowish brown, the remaining segments brownish black. Antennæ (male) relatively short, if bent backward extending about to the wing root; scape and pedicel yellow, flagellum dark brown; basal enlargement of segments of medium size; verticils exceeding the segments; terminal segment about one-half the penultimate. Head buffy yellow.

Mesonotum obscure yellow or grayish yellow, with a poorly indicated, more brownish yellow, median stripe that is best indicated by the narrow brown margins; lateral stripes obsolete; scutum yellowish gray, the centers of lobes somewhat darker; posterior sclerites of mesonotum more buffy. Pleura buffy yellow, the dorsopleural membrane somewhat clearer. Halteres pale, the knobs darkened. Legs with the coxæ pale yellow; trochanters yellow; femora yellow, the tips narrowly and weakly darkened; tibiæ and tarsi brownish yellow, the outer tarsal segments more darkened. Wings (Plate 1, fig. 11) yellowish gray; prearcular and costal regions clearer yellow; stigma brown; obliterative areas at cord conspicuous; veins brown. Venation: R_{1+2} entire; cell 1st M_2 small; M_{3+4} about one-half the basal section of M_3.

Abdomen with the basal segments yellow, narrowly trivittate with brown, the sublateral stripes more distinct than the median one; segments eight and nine blackened. In the female, the three tergal stripes are broader and more distinct, especially on outer segments. Male hypopygium (Plate 3, fig. 39) large; tergite, 9*t*, entirely separated from sternite, 9*s*, by wide membrane; basistyle large but incomplete, separated from sternite by a deep, membranous, ventral suture and a longer but fainter dorsal impressed line. Ninth tergite (Plate 3, fig. 39, *9t*) of moderate size, gently narrowed outwardly, the caudal margin with a U-shaped notch; sublateral lobes obtuse, near apex with a small, slender protuberance that is directed ventrad and mesad; on ventral face of tergite, in longitudinal alignment with the above, a second pair of similar darkened lobules. Outer dististyle (Plate 3, fig. 40, *od*) broadly spatulate. Inner dististyle, *id*, with a conspicuous caudal or outer arm, the apex of which is truncated, the outer margin of both arms of style fringed with long setæ. Ninth sternite, at junction with basistyle, with a pendulous lobe that is densely clothed with long yellow setæ; cephalad of this, a conspicuous armature of chitinized hooks, as shown. Eighth sternite (Plate 3, fig. 40, *8s*) unusually complicated by lobes and setal brushes; median region with a deep emargination filled with membrane, bearing two pairs of lobes: A larger, more caudal pair, before apex with a powerful reddish spine decussate at midline with its mate of the opposite side; inner face of this lobe with abundant long yellow setæ that extend the entire length of lobe, the more basal ones coarser; the more cephalic pair of sternal lobes lie closer to the midline, each with a long brush of yellow setæ that are directed ventrad. Ovipositor with cerci long and slender, straight.

Habitat.—Eastern Siberia (Kamchatka).

Holotype, male, Kljuchevskoje Village, 160° 20′ east longitude, 56° 40′ north latitude, June 2, 1909 (*Dershavin*), No. 364. Allotopotype, female, July 6, 1909, 363. Paratopotype, male, June 15, 1909, No. 366.

The present fly is very distinct from other regional members of the subgenus. It is allied to European species such as *Tipula peliostigma* Schummel, *T. selene* Meigen, and others, but is well-distinguished by the size and structure of the male hypopygium.

TIPULA (LUNATIPULA) LAMENTARIA sp. nov. Plate 1, fig. 12; Plate 3, figs. 41, 42.

General coloration gray and yellow, the præscutum with more brownish gray stripes that are poorly delimited; basal three antennal segments yellow, the remainder chiefly brownish black; wings pale brown, sparsely variegated by darker brown and whitish; petiole of cell M_1 short, cell 1st M_2 long; male hypopygium with the tergite large, the median region entirely pale, membranous; each lateral lobe flattened, divergent; a single dististyle; a conspicuous fleshy lobe extends caudad from the posterior portion of the basistyle; eighth sternite with a terminal brush of yellow setæ.

Male.—Length, about 13 millimeters; wing, 15.5; antenna, 4.5.

Frontal prolongation of head testaceous-yellow; nasus slender; palpi brownish black. Antennæ (male) of moderate length, if bent backward extending about to mid-distance between the bases of wings and halteres; basal three segments of antennæ light yellow; remainder of organ almost uniformly brownish black, the basal enlargements a little darker; verticils very long, exceeding the segments. Head gray.

Mesonotal præscutum gray, with darker, more brownish gray stripes that are very poorly defined; scutal lobes variegated by darker; scutellum brown; mediotergite testaceous-yellow. Pleura brownish yellow, the dorsopleural region clearer yellow; ventral sternopleurite weakly darkened. Halteres pale yellow, the knobs infuscated. Legs with the coxæ whitish yellow; trochanters yellow; femora light yellow, the tips narrowly but conspicuously blackened; tibiæ pale brown, the tips darker; tarsi pale brown, the outer segments darker brown. Wings (Plate 1, fig. 12) with the ground color pale brown; prearcular and costal regions light yellow; stigma small, pale brown, confluent with a cloud on anterior cord; small but conspicuous obliterative areas before stigma and across cell 1st M_2; veins brown, paler in the yellow areas. Macrotrichia of veins beyond cord relatively numerous, lacking on distal half of R_{1+2}. Venation: R_{1+2} entire; cell M_1 with petiole short, varying in length from about one-half m to subsessile; cell 1st M_2 long, parallel-sided; M_{3+4} short, less than one-third the basal section of M_3, the fork thus lying proximad of r-m.

Abdomen more or less discolored in type, apparently dark reddish brown, the outer segments still more darkened. Male hypopygium (Plate 3, fig. 41) with the tergite, *9t*, entirely separate from the sternite, *9s*, by membrane; basistyle very small, entirely cut off by sutures; at point of union of sternite and basistyle is a stout cylindrical lobe, directed caudad, pale in color, provided with long conspicuous setæ. Ninth tergite (Plate 3, fig. 42, *9t*) large, each half entirely divided by pale membrane, the lateral lobes appearing as broad, flattened, divergent blades that gradually narrow to the subacute tips; median-caudal portion of tergite a little produced, the margin obtuse. A single dististyle (Plate 3, fig. 41, *d*), compressed, the posterior margin coarsely and irregularly denticulate; surface of style with scattered setæ, those at point of attachment of basistyle very abundant and delicate. Eighth sternite (Plate 3, fig. 41, 8*s*) moderately sheathing, narrowed outwardly, the apex gently notched and provided with a brush of long yellow setæ. Ædeagus (Plate 3, fig. 42, *a*) elongate, blackened, the apex terminating in two acute black spines.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, between Chhil and Wakar, Amur River, July 29, 1908 (*Soldatov*), No. 661.

The general appearance of the present fly is somewhat like the Nearctic *Tipula mainensis* Alexander, but the two species are very distinct. The broad membranous median strip of the tergite of the hypopygium is similar to that found in many *Vestiplex* species. In certain structures, the fly suggests some European species of *Lunatipula,* as *peliostigma* Schummel and *selene* Meigen, but the resemblance is not particularly close.

TIPULA (LUNATIPULA) LUNDSTRÖMIANA sp. nov. Plate 1, fig. 13; Plate 4, figs. 43, 44, 45.

Belongs to the *serta* group; nasus lacking; general coloration gray, the præscutum with four brown stripes; antennæ (male) long, the flagellar segments strongly incised; male hypopygium with the caudal margin of sternite produced medially into a depressed plate that is further extended into two long straight spines.

Male.—Length, about 16 millimeters; wing, 16; antenna, about 6.5.

Female.—Length, 22 to 23 millimeters; wing, 19 to 20.

Frontal prolongation of head elongate, without nasus, brownish gray above, brighter laterally beneath; palpi brownish black. Antennæ of male (Plate 4, fig. 43) long, if bent backward extending to shortly beyond base of abdomen; scape and pedicel yellow, flagellum black; flagellar segments very strongly incised, about as in *excisa.* Head light gray, with a capillary blackish line on posterior vertex.

Mesonotal præscutum light gray, with four brown stripes; scutum light gray, the lobes variegated with darker gray; posterior sclerites of notum gray, the mediotergite with a median dusky vitta. Pleura gray, the dorsopleural region light yellow; mesopleura glabrous. Halteres yellow, the knobs dark brown. Legs with the coxæ light gray; trochanters yellow; femora yellow, the tips narrowly and gradually infuscated; tibiæ yellowish brown, darkened outwardly; tarsi black. Wings (Plate 1, fig.

13) brownish, the prearcular and costal regions more yellowish; stigma dark brown; anterior cord clouded with brown; an incomplete whitish crossband beyond stigma, extending to cell 1st M_2 (male) or into base of M_3 (female); a whitish spot near outer end of cell M, small in male, larger and more conspicuous in female; veins brown. Macrotrichia of veins beyond cord numerous and well-distributed; squama naked. Venation: $_{1+2}$ entire, with trichia to tip or nearly so; cell 1st M_2 long, narrowed at outer end; M_{3+4} varying from very short, about one-half m, to fully as long as this element.

Abdomen with the first tergite brown, the succeeding segments yellow, the tergites weakly darkened medially, much more strongly so in female; indications of a less clearly defined sublateral stripe; lateral margins narrowly pale; outer segments infuscated; sternites of female darkened and pruinose. Male hypopygium (Plate 4, fig. 44) with the tergite, *9t*, separate from sternite, *9s;* basistyle, *b*, very large, entirely separate, the caudal end narrowed but scarcely produced. Ninth tergite (Plate 4, fig. 45, *9t*) subquadrate, transverse; caudal margin with five projections, including a nearly lateral pair of slender flattened blades, their tips obtuse; a shorter and broader median black lobe, and a pair of small acute teeth between the other projections; dorsomedian region of tergite narrowly impressed, without setæ; lateral lobes, viewed from side, with a ventral expansion near base. Outer dististyle, *od*, cylindrical, slender, with abundant coarse setæ. Inner dististyle (Plate 4, fig. 45, *id*) tridentate at apex. Region of junction of ninth sternite and basistyle (Plate 4, fig. 44, *9s*) with a long pale fleshy lobe directed ventrad and mesad, the narrowed tips contiguous on the midline. Eighth sternite (Plate 4, fig. 45, *8s*) with the caudal margin transverse or nearly so, the only armature being a conspicuous median depressed plate that narrows outwardly, terminating in two acute straight spines that inclose a deep, parallel-sided U-shaped notch. As in the similar bidentate lobe of *serta*, there is some variation in size and shape of the plate in different individuals.

Habitat.—Eastern Siberia (Amur, Saghalien).

Holotype, male, Beitonovo Station, Amur River, May 31, 1915 (*Popoff*), No. 630. Allotopotype, female, No. 631. Paratypes, 1 teneral male, Osernaja, Amur River, June 10, 1913, No. 664; 1 male, Saghalien (*Suprunenko*), No. 526; 1 female, Amur (*Suprunenko*), No. 529.

I dedicate this distinct species to the memory of the late Carl Lundström, distinguished authority on the Nematocera of Finland and Arctic Asia. The closest allies are *T. subexcisa* Lundström, of northern Europe, and *T. serta* Loew, of northern North America; from the former it is readily told by the armature of the eighth sternite of the male hypopygium, where the small, widely separated fleshy lateral lobes of *subexcisa* are replaced by the median bidentate plate described; *serta*, while very different from the present species in its general appearance, especially the wing pattern, approaches it in the structure of the male hypopygium, the general features being very similar in the two flies. The bidentate sternal plate is smaller in *serta*, but has nearly the same conformation. I believe that the members of the *serta* group are correctly placed in *Lunatipula* despite the conspicuous lack of a nasus.

TIPULA (LUNATIPULA) FLACCIDA sp. nov. Plate 1, fig. 14; Plate 4, figs. 47, 48.

Belongs to the *serta* group; general coloration of mesonotum light gray, with four slightly darker gray stripes; antennæ (male) relatively long, the flagellar segments only feebly incised; femora yellow, the tips narrowly dark brown; wings grayish, with a restricted whitish and dark brown pattern; male hypopygium with a small obtuse median lobe between the slender lateral arms of tergite; eighth sternite with a horn-shaped lobe on either side, these gradually narrowed to the tips.

Male.—Length, about 16 millimeters; wing, 17.5; antenna, about 6.

Frontal prolongation of head long and conspicuous, brown, sparsely pruinose dorsally, more yellowish ventrally beneath; nasus lacking; palpi with basal segment yellow, succeeding segments pale brown, the terminal segment passing into brownish black. Antennæ (Plate 4, fig. 46) relatively long; basal three segments yellow, the remainder brownish black; flagellar segments only feebly incised; longest verticils about equal to the segments. Head light gray, with a faintly indicated median dusky vitta.

Mesonotal præscutum light gray, with four scarcely indicated darker gray stripes, the intermediate pair separated by a darker vitta; scutum light gray, the lobes indistinctly variegated by darker gray; posterior sclerites of notum gray. Pleura light gray, with large darker gray areas on ventral anepisternum, ventral sternopleurite, and meron; dorsopleural region yellow. Halteres yellow, the knobs dark brown. Legs with the coxæ gray; trochanters yellow; femora yellow, the tips narrowly dark brown, the amount subequal on all legs and not exceeding the distal seventh or eighth; tibiæ and tarsi brown, the outer tarsal segments blackened. Wings (Plate 1, fig. 14) grayish, with a restricted whitish and dark brown pattern that is arranged much as in *sublimitata;* post-stigmal whitening restricted, including cells Sc_2 and R_2; obliterative streak along cord more extensive and conspicuous, involving the base of cell M_3; stigma dark brown; narrow brown seams on anterior and posterior cords; veins brown. Macrotrichia of veins numerous. Venation: Second section of R_1 slightly shorter than free tip of Sc_2.

Abdomen yellow, the tergites trivittate with brown, the areas extensive but not well-delimited; terminal segments and hypopygium uniformly blackened. Male hypopygium (Plate 4, fig. 47) of moderate size, the tergite, *9t,* and basistyle, *b,* entirely cut off from sternite, *9s,* by deep, membranous sutures. Ninth tergite (Plate 4, fig. 47, *9t*) narrowed outwardly, the caudal margin conspicuously emarginate; lateral lobes narrowed into slender blackened blades, their tips truncated; at base of emargination a small obtuse blackened lobe. Basistyle with a group of long scattered setæ. Outer dististyle small, cylindrical. Inner dististyle (Plate 4, fig. 48, *id*) with a conspicuous digitiform lobe at base. Junction of sternite and basistyle with a blackened lobe that is directed ventrad, provided with sparse scattered yellow setæ. Eighth sternite (Plate 4, fig. 48, *8s*) having the surface with small delicate setæ only; caudal margin with a broad notch filled with membrane; a horn-shaped lobe at each lateral angle of emargination, each narrowed to a subacute point, the mesal surface with a few, scattered, coarse, yellow setæ.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Volok Bay, Vladivostok, August 4, 1912 (*Czerski*), No. 727.

The nearest ally is *Tipula* (*Lunatipula*) *sublimitata* Alexander, of Kamchatka,[4] which differs chiefly in the structure of the male hypopygium, especially the tergite and eighth sternite. In the latter species, the lateral lobes of the sternite are broad-based with the tips blunt and expanded.

TIPULA (LUNATIPULA) DERSHAVINI sp. nov. Plate 1, fig. 15; Plate 4, fig. 49.

Allied to *senega;* general coloration of mesonotum olive-gray, the præscutum with four ill-defined darker gray stripes; antennæ with three basal segments yellow, the remainder chiefly brownish black; wings with a faint brown tinge, an incomplete whitish crossband beyond cord; male hypopygium with the tergite notched, produced medially into an obtuse triangular lobe; eighth sternite produced medially into a flattened plate, the apex notched, the ventral margins toothed.

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[4] Arkiv för Zoologi 19A, No. 9 (1927) 8–10, figs. 4, 5.

Male.—Length, about 14 millimeters; wing, 15; antenna, about 4.5.

Female.—Length, about 20 millimeters; wing, 18.5.

Frontal prolongation of head obscure yellow; nasus conspicuous; palpi dark brown, the basal segment obscure yellow. Antennæ with the basal three segments yellow, the remainder nearly uniform brownish black, the basal enlargements a little darker; flagellar segments moderately incised; verticils nearly as long as the segments; terminal segment small, thimble-shaped. Head olive-gray, the midline of posterior vertex a little darkened.

Mesonotal præscutum olive-gray, with four darker brownish gray stripes that are ill-defined against the ground, the mesal edges of anterior ends of intermediate stripes a little darker; scutum greenish gray, the lobes variegated with darker; posterior sclerites of notum chiefly gray. Pleura whitish, the ventral anepisternum and ventral sternopleurite light gray; dorsopleural membrane buffy; pleura glabrous. Halteres yellow, the knobs infuscated. Legs with the coxæ obscure whitish; trochanters yellow; femora obscure yellow, the narrow tips weakly and very indistinctly darkened; tibiæ brownish yellow; tarsi passing into brownish black. Wings (Plate 1, fig. 15) with a faint brown tinge; prearcular and costal regions clearer yellow; stigma and a narrow brown seam on anterior cord pale brown; an incomplete whitish crossband beyond cord, extending from costa to cell 1st M_2, narrowed behind; whitish obliterative areas before stigma and across cell 1st M_2; veins brown. Macrotrichia on veins beyond cord sparse but well-distributed; squama without well-developed setæ. Venation: R_{1+2} entire; M_{3+4} short, less than m.

Abdominal tergites obscure brownish yellow, with a broad diffuse brownish median stripe and narrow, interrupted, sublateral, brown stripes; lateral borders of segments broadly grayish white; sternites yellow, the outer segments more darkened. Male hypopygium (Plate 4, fig. 49) with the tergite, *9t*, separate from sternite, *9s;* basistyle relatively large, almost completely separated from sternite, fused for a short distance near the ventral suture. Ninth tergite, *9t*, of the general type of *senega* or *serta;* lateral lobes relatively slender; median area conspicuously produced into a blunt triangular point. From the membrane at end of ventral suture of basistyle hangs pendant a large pale fleshy lobe that is clothed with abundant pale setæ. Basistyle with outer end narrowed to an obtuse point. Outer dististyle very small, cylindrical, with conspicuous setæ. Inner dististyle, *id,* massive. Phallosome, *p,* trifid, the median lobe microscopically bifid at apex. Eighth sternite, 8*s*, with the caudal margin complexly armed; lateral lobes with margins feebly sclerotized, directed mesad, touching one another at midline, clothed with relatively conspicuous setæ; median region of sternite produced caudad into a flattened chitinized blade, depressed, the apex with a U-shaped notch, the ventral margins (as viewed laterally) thickened and set with about three conspicuous teeth; at base of median plate, just cephalad of the lateral lobes, a small acute point that is directed strongly caudad.

Habitat.—Eastern Siberia (Kamchatka, Ussuri).

Holotype, male, Kljuchevskoje Village, Kamchatka, 160° 20′ east longitude, 56° 40′ north latitude, July 5, 1909 (*Dershavin*), No. 358. Allotype, female, Suchan district, Trolovka, Ussuri, July 6, 1926 (*Mordvilko*), No. 619. Paratopotype, female, with type, No. 356.

The present fly is undoubtedly allied to the Nearctic *Tipula senega* Alexander, despite the somewhat different wing pattern. The peculiar conformation of the ninth tergite and eighth sternite of the male hypopygium are very suggestive of the same structures in *senega,* but the details are quite distinct. The superficial appearance is much as in the Japanese *Tipula pendula* Alexander, but the hypopygium of the latter is entirely different. The paratype may not be conspecific with the type, as the white band beyond cord of wings is not defined and the tips of the femora are narrowly darkened.

TIPULA (LUNATIPULA) LÆTIBASIS sp. nov. Plate 1, fig. 16; Plate 4, figs. 50, 51.

Allied to *sachalinensis;* general coloration gray, the mesonotal præscutum with four darker gray stripes, the intermediate pair narrowly separated and without further median darkening; wing base conspicuously light yellow; male hypopygium with the caudal margin of tergite broadly emarginate, without denticles except a single outer point on each lobe; inner dististyle with the heel portion dusky, terminating in several small spines.

Male.—Length, about 13 to 14 millimeters; wing, 12 to 12.5.

Female.—Length, 18 to 22 millimeters; wing, 13.5 to 16.5.

Generally similar and closely allied to *Tipula sachalinensis* Alexander, differing especially in the coloration of the mesonotal præscutum and in the structure of the male hypopygium.

Coloration bluish gray, the head with a median darker line. Mesonotal præscutum with four dark stripes, the intermediate pair clearly but narrowly separated and without indications of a further capillary median vitta, as in *sachalinensis;* lateral margins of præscutum undarkened. Femoral tips conspicuously blackened, somewhat more broadly so in the Honshu paratype. Wings (Plate 1, fig. 16) with the prearcular cells conspicuously light yellow in both sexes; dark pattern highly contrasted, especially in female. Abdomen with caudal margins of outer segments conspicuously ringed with yellow, the lateral margins of tergites more buffy; abdomen with a heavy light gray bloom. Male hypopygium in essentials much as in *sachalinensis,* as in the notched ninth tergite, complete basistyle, and armed eighth sternite. Ninth tergite (Plate 4, fig. 50, 9*t*) with the caudal margin gently emarginate to form a large U-shaped notch, the base of which has a further quadrate incision that bears a tiny median tooth at base; no denticles along caudal border of tergite; dorsal surface back from median incision with a depressed groove. Outer dististyle cylindrical. Inner dististyle, *id,* much as in *sachalinensis,* but the heellike portion is borne on side of sclerite, appearing as a dusky plate having each outer angle with about three coarse teeth. Junction of ninth sternite and basistyle on either side with a small lobe that is suddenly narrowed outwardly, the apex tufted, 9*s*. Eighth sternite with the caudal margin emarginate, filled with pale membrane; each lateral angle bears a pencil of long setæ, mesad of which are smaller setæ.

In *Tipula sachalinensis* the tergite (Plate 4, fig. 51, 9*t*) has the caudal margin transverse or even slightly convex, with a deep median notch, the lateral lobes thus formed truncate, with small spinous points. Inner dististyle, *id,* with the heel portion projecting as a subrectangular yellow lobe, its apex truncated, the surface with delicate microscopic setulæ, but without spines of any sort. Lobes of the ninth sternite longer, more evenly cylindrical, with long conspicuous setæ.

Habitat.—Eastern Siberia, Japan.

Holotype, male, Bay De Castries, Ussuri, June 19, 1910 (*Derbeck*), No. 318. Allotype, female, River Kamchatka, Kamchatka, 1898 (*Gondatti*), No. 590. Paratypes, 1 female, Dshalinda, Reinovo, Amur, June 9 to 30, 1915 (*Poroff*), No. 624; 1 female, Ichinosawa, Saghalien, July 9, 1924 (*M. Tamanuki*); 1 female, Norikuradake, Japanese Alps, Honshiu, Japan, July 26, 1929 (*Machida*).

The only fly that can be confused with *Tipula* (*Lunatipula*) *lætibasis* is *T.* (*L.*) *sachalinensis* Alexander, which has been sufficiently compared in the above description. The Japanese paratype had earlier [5] been recorded as *sachalinensis*, but the discovery of the male sex has shown the present fly to be quite distinct.

TIPULA (LUNATIPULA) GONDATTII sp. nov. Plate 1, fig. 17; Plate 4, figs. 52, 53.

Allied to *trispinosa;* mesonotum light gray, the præscutum with four, scarcely evident, darker gray stripes; wings with the ground color yellowish gray, stigma pale brown; male hypopygium with the outer lateral angles of tergite produced into slender blackened horns; outer dististyle very small.

Male.—Length, about 11 to 13 millimeters; wing, 12.5 to 14; antenna, about 4.

Female.—Length, about 12 millimeters; wing, 12.

Frontal prolongation of head relatively long, gray; nasus lacking; palpi brown, the incisures pale. Antennæ with the scape infuscated; pedicel light yellow; flagellum black; segments with basal enlargement moderately developed, the verticils a trifle shorter than the segments. Head gray.

Mesonotal præscutum light gray, with four scarcely apparent darker gray stripes, the lateral pair especially indistinct; posterior sclerites of notum gray, the scutellum a little more yellowish. Pleura gray, the posterior sclerites paler; dorsopleural region yellow. Halteres yellow, the knobs infuscated. Legs with the coxæ light gray; trochanters yellow; femora yellow, the tips conspicuously blackened, the amount subequal on all legs, including approximately the distal sixth or less; tibiæ and tarsi light brown, the terminal tarsal segments darker brown. Wings (Plate 1, fig. 17) yellowish gray, the prearcular and costal regions light yellow; stigma pale brown; obliterative streak before cord relatively conspicuous, extending into base of cell M_3; veins pale brown, more yellowish in the brightened areas. Macrotrichia well distributed on veins beyond cord. Venation: R_{1+2} entire; cell 1st M_2 of moderate size for a member of the group.

Abdominal tergites reddish yellow, on the fourth and succeeding segments more blackish gray, with broad pale lateral margins; sternites beyond the second blackish gray; hypopygium black. Male hypopygium (Plate 4, fig. 52) with the tergite, 9*t*, and basistyle entirely distinct from sternite, the latter small. Ninth tergite (Plate 4, fig. 52, 9*t*) large, black, with a profound spade-shaped median incision, the lateral arms narrowed into slender, gradually diverging lobes, the cephalic sclerotized bar narrow. Outer dististyle a tiny blacked lobe. Inner dististyle (Plate 4, fig. 53, *id*) relatively small, extended into a simple apical beak. Eighth sternite (Plate 4, fig. 53, 8*s*) sheathing, each outer lateral angle bearing a slender, inconspicuous lobe that is narrowed to an acute point, the surface with small setulæ. Ovipositor with small fleshy valves, as in the *fascipennis* group.

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[5] Philip. Journ. Sci. 44 (1931) 339.

Habitat.—Eastern Siberia (Saghalien, Ussuri).

Holotype, male, Nikolajevsk, Amur River, Ussuri, June 23, 1914 (*Bjeloussov*), No. 535. Allotopotype, female, No. 537. Paratopotype, 1 female, No. 536. Paratypes, 2 males, Chaivo, Saghalien, 142° east longitude, 52° north latitude, July 12, 1910 (*Derbeck*), Nos. 322, 324; 4 of both sexes, Dui, Saghalien, June 20, 1914 (*Bjeloussov*), Nos. 544, 545, 547, 550.

I take pleasure in dedicating this distinct fly to Mr. Gondatti, leader of several expeditions to eastern Siberia in behalf of the Russian Academy of Sciences. The nearest ally is *Tipula* (*Lunatipula*) *trispinosa* Lundström, of Finland, which has all details of the male hypopygium quite distinct.

TIPULA (LUNATIPULA) DERBECKI sp. nov. Plate 1, fig. 18; Plate 5, fig. 54.

General coloration gray, the præscutum with four, poorly defined, darker gray stripes; antennæ (male) short, if bent backward not reaching the wing root; scape and pedicel yellow; flagellum with basal segments bicolorous; femora yellow, the tips narrowly brownish black; wings grayish brown with a restricted brown and white pattern, the former including a conspicuous spot at near midlength of cells M and Cu; a short poststigmal white crossband; R_{1+2} entire; male hypopygium with the ninth tergite notched medially, the lateral lobes broad; inner dististyle with caudal end produced into a long, powerful, black spine; eighth sternite moderately sheathing, terminating in two small, fleshy, pendant lobes.

Male.—Length, about 13.5 millimeters; wing, 15; antenna, about 3.

Frontal prolongation of head black, sparsely pruinose; nasus long and slender; palpi black. Antennæ (male) relatively short, if bent backward ending some distance before wing root; scape and pedicel yellow; basal flagellar segments bicolorous, black basally, reddish brown apically, the outer segments more uniformly blackened; longest verticils nearly equal in length to segments. Head gray pruinose, discolored in type.

Mesonotum gray, the præscutum with poorly defined darker gray stripes; scutal lobes similarly marked with dark gray; scutellum dark gray; mediotergite light gray. Pleura gray; dorsopleural region buffy. Halteres pale yellow, knobs dark brown. Legs with the coxæ light gray; trochanters yellow; femora yellow, the tips narrowly brownish black; tibiæ yellow, the tips narrowly darkened; tarsi obscure yellowish brown at base, passing into black; forelegs broken. Wings (Plate 1, fig. 18) with the ground color grayish brown, with a restricted brown and whitish pattern; the brown areas include the stigma and a confluent area on anterior cord; a small spot at origin of Rs; a large paler brown cloud at midlength of cells M and Cu, preceded and followed by more-whitish areas; a restricted whitish mark beyond stigma, extending from costa to cell R_5, becoming more obscure behind; axilla narrowly darkened; veins brown. Macrotrichia of veins very numerous, lacking on 1st A, with exception of a single trichium at outer end; squama naked. Venation: R_{1+2} pale, entire, diverging strongly from R_3, cell R_2 relatively small; M_{3+4} about two-thirds the basal section of M_3.

Abdomen with basal tergite gray; tergites two and three yellow, narrowly trivittate with brown, on the outer segments becoming more extensive so as to include virtually the whole segment; lateral borders of tergites pale; basal sternites yellow, the outer segments dark brownish gray. Male hypopygium (Plate 5, fig. 54) with the tergite, *9t*, entirely separate from the sternite, *9s*, by extensive pale membrane. Basistyle, *b*, very large, the suture separating it from sternite delicate but complete. Ninth tergite, *9t*, broad, darkened but not heavily sclerotized, the main body massive, the caudal margin extended into a paler portion that bears a U-shaped median notch; lateral lobes very broad, obliquely truncated; mid-dorsal area of tergite depressed, without setæ. Outer dististyle, *od*, pale, long, and slender, still paler and more or less constricted at midlength, the apex narrowed. Inner dististyle, *id*, elongate, parallel-sided or even a little dilated outwardly, the ventral or caudal end produced into a powerful smooth black spine, its apex acute. Eighth sternite sheathing, the apex at midline with two small pale lobes that are pendant or recurved.

Habitat.—Eastern Siberia (Amur).

Holotype, male, Cape Dshaore, mouth of Amur River, 141° 15′ east longitude, 53° north latitude, June 19, 1910 (*Derbeck*), No. 312.

This very interesting *Tipula* is dedicated to the collector of this and other noteworthy crane flies from Amur and Saghalien. The peculiar structure of the male hypopygium, especially of the inner dististyle, readily separates the present fly from allied similar forms. The spinous extension of the inner dististyle suggests *Tipula apicispina* Alexander (Ussuri), which is in all other respects a very different fly.

TIPULA (LUNATIPULA) CHERNAVINI sp. nov. Plate 1, fig. 19.

General coloration gray, the præscutum with four dark brown stripes; antennæ black, the basal three segments yellow, the proximal end of scape a little darkened; femora obscure yellow, the tips rather narrowly brownish black; wings handsomely variegated with light and dark brown, together with extensive whitish areas, the latter including a complete crossband beyond cord; R_{1+2} entire; cell M_1 unusually deep, sessile; basal abdominal tergites reddish yellow, with three brown stripes; basal sternites dark gray.

Female.—Length, about 20 millimeters; wing, 18.5.

Frontal prolongation of head light gray above, the ventral half beneath brownish black; nasus elongate, stout; palpi black. Antennæ with the basal three segments yellow, the proximal end of scape a little infuscated, the first flagellar segment a little more darkened than the pedicel; remainder of antennæ black; longest verticils exceeding segments; terminal segment nearly two-thirds the penultimate. Head light gray.

Mesonotal præscutum light gray with four dark brown stripes, the intermediate pair narrow and more intense in color than the laterals; scutal lobes variegated with dark brown; posterior sclerites of notum gray, the mediotergite with a capillary dark line. Pleura gray, the dorsopleural region more buffy. Halteres broken. Legs with the coxæ light gray; trochanters yellow; femora obscure yellow, the tips rather narrowly brownish black; tibiæ light brown, the tips narrowly blackened; tarsi light brown at bases, passing into black. Wings (Plate 1, fig. 19) with the ground color relatively dark brown, highly variegated with whitish and darker brown; prearcular and costal regions yellow; stigma dark brown, confluent with a similar area on anterior cord; dark spot at origin of Rs small; the extensive white areas are as follows: A broad complete crossband beyond cord; extensive areas in cells R_1, outer end of cell R, the latter confluent with a similar but smaller area in outer end of cell M; a large basal whitening, involving cells R to 1st A, inclusive; bases of anal cells pale; veins brown, light yellow in the whitish areas. Macrotrichia of veins beyond cord relatively numerous and well-distributed; squama naked. Venation: R_{1+2} entire but very pale beyond base; cell M_1 sessile; M_{3+4} less than one-half the basal section of M_3; m-cu on M_4 shortly beyond origin.

Abdomen destroyed beyond midlength; basal tergite and proximal ring of tergite two dark gray; succeeding tergites reddish yellow, the median region dark brown; on third and succeeding tergites a conspicuous sublateral stripe begins; basal four sternites dark gray, with only the base of second narrowly yellow; segments beyond fourth broken.

Habitat.—Eastern Siberia (Amur).

Holotype, female, Osernaja, mouth of Amur River, 160° 30′ east longitude, 57° north latitude, June 20 and 21, 1915 (*Chernavin*), No. 713.

This interesting crane fly is named in honor of the collector, who has taken rather numerous species of these flies at the mouth of the Amur. The fly belongs to a group of forms having vein R_{1+2} entire and with a broad, complete white crossband beyond the cord. From all regional members of this restricted group, it differs in the sessile cell M_1. The closest relative appears to be *Tipula (Lunatipula) mesacantha* sp. nov., which has cell M_1 conspicuously petiolate, and, in the male sex, at least, has the basal abdominal sternites brightened. The possibility exists that the present fly is the opposite sex of *mesacantha.*

TIPULA (LUNATIPULA) MESACANTHA sp. nov. Plate 1, fig. 20; Plate 5, figs. 55, 56.

Allied to *trupheoneura;* general coloration light gray, the præscutum with four more or less distinct brown stripes; antennæ with scape and pedicel yellow, flagellum black; wings pale brown, variegated by darker brown and whitish areas, the latter including a complete crossband beyond cord; tip of R_{1+2} pale or atrophied; male hypopygium with the lateral lobes of tergite flattened, pale, the margins irregularly toothed; median notch of tergite with a long acute spine; dorsocaudal region of ninth sternite on either side bearing two conspicuous spines of unequal sizes.

Male.—Length, about 13 to 14 millimeters; wing, 14.5 to 16; antenna, about 4 to 4.2.

Frontal prolongation of head obscure yellow, slightly pruinose above, more heavily so at base; nasus short and stout; palpi black. Antennæ with the scape and pedicel light yellow; first flagellar segment obscure yellow at base, the outer end infuscated; remainder of flagellum almost uniformly brownish black; flagellar segments moderately incised; longest verticils nearly equal in length to segments; terminal segment a mere button. Head light gray, with a median brown line, more distinct on posterior vertex; vertical tubercle relatively large.

Mesonotal præscutum light gray, with four narrow brown stripes, these subobsolete in the paratype; scutum light gray, each lobe with two conspicuous brown areas, subobsolete in paratype; scutellum brownish gray; mediotergite gray with a capillary blackish median vitta. Pleura light gray, the dorsopleural region light yellow; no setæ on mesepisternum. Halteres pale yellow, the knobs dark brown. Legs with the coxæ light gray; trochanters yellow; femora yellow, the tips brownish black, the amount subequal on all legs; tibiæ reddish brown, not or scarcely darker at tips; tarsi brown to dark brown; tibial spur formula 1–2–2; claws small, simple. Wings (Plate 1, fig. 20) pale brown, variegated by darker brown areas and very extensive whitish markings; the dark areas include the stigma and a confluent mark on anterior cord, together with a small brown spot at origin of Rs; the whitish areas include a complete crossband beyond cord, with very extensive pale areas in cells R_1, R, M, and Cu, restricting the ground almost entirely to markings in outer half of cell M; anal cells whitened basally and at near midlength of cell 1st A; prearcular and costal regions light yellow; veins brown, becoming yellowish where traversing the pale markings. Squama naked. Venation: Extreme tip of R_{1+2} very faint (in type) to entirely atrophied (in paratype), the distal two-thirds without trichia; m-cu on M_4 beyond origin.

Basal abdominal tergites reddish, with a median dark brown vitta; lateral borders narrowly gray, bordered internally by a scarcely evident dusky line; basal sternites yellow; outer abdominal segments infuscated, the hypopygium dark brown. Male hypopygium (Plate 5, fig. 55) with the tergite, 9*t*, entirely separate from the sternite, 9*s;* basistyle, *b*, entirely distinct from sternite, its caudal margin slightly but broadly produced. A small sclerite cut off from the dorsocaudal region of the ninth sternite is produced into a strong blackened spine, directed chiefly dorsad and caudad, with a second smaller spine near its base, 9*s*. Ninth tergite (Plate 5, fig. 56, 9*t*) flattened, pale in color, the nearly lateral lobes thin, obliquely truncated at tips, the margin of lobes with weak pale denticles; the deep quadrate median notch bears at its base an unusually long and powerful acute spine that is approximately as long as the mesal edge of the lateral tergal lobes; on ventral surface of tergal plate, at base of each lobe and near the mesal edge, a small acute blackened spine, directed ventrad. Outer dististyle a setiferous clavate lobe. Inner dististyle with two blacked beaks, the outer margin near base produced into a small rounded lobe that bears several coarse black setæ.

Habitat.—Eastern Siberia (Amur, Ussuri).

Holotype, male, Osernaja, mouth of Amur River, June 20 and 21, 1915 (*Chernavin*), No. 715. Paratype, male, Golden Horn, Vladivostok, May 28, 1911 (*Rydzevski and Kuznetzov*), No. 426.

Tipula (*Lunatipula*) *mesacantha* is related to the Japanese *T.* (*L.*) *pollex* Alexander and *T.* (*L.*) *trupheoneura* Alexander, especially to the latter, but is quite distinct in the structure of the male hypopygium, the more conspicuous features being the ninth tergite, unarmed basistyle, and double spine of caudal margin of ninth sternite. As discussed under *T.* (*L*). *chernavini* sp. nov., the possibility exists that this may be the male sex of that fly.

TIPULA MEDIOLOBATA sp. nov. Plate 1, fig. 21; Plate 5, figs. 57, 58.

Allied to *luteipennis;* general coloration of thorax gray, the præscutum with four slightly darker gray stripes that are feebly bordered by brown; male hypopygium with the tergite broadly emarginate, at base with a conspicuous median lobe that is clothed with abundant setulæ.

Male.—Length, about 13.5 to 14 millimeters; wing, 14 to 15.

Female.—Length, about 16 to 18 millimeters; wing, 15 to 16.

Frontal prolongation of head yellow; nasus distinct; basal segments of palpi yellow, outer segments broken. Antennæ with scape and pedicel yellow; flagellum broken. Head gray, the vertex medially a little darker.

Mesonotal præscutum gray, with scarcely differentiated gray stripes that are best indicated by pale brown margins; posterior sclerites of notum light gray. Pleura gray, the dorsopleural region buffy. Halteres yellow, the knobs infuscated. Legs with the coxæ light gray; trochanters yellow; femora yellow, the tips conspicuously blackened, of the tibiæ more narrowly so; tarsi passing into black. Wings (Plate 1, fig. 21) with a strong yellow tinge; stigma pale brown; obliterative streak before cord conspicuous; veins brown. Venation: R_{1+2} and R_3 only gradually divergent; petiole of cell M_1 short, subequal to or shorter than m.

Abdomen yellow, the basal segment pruinose; tergites with a conspicuous median brown vitta, with much narrower and less evident lateral stripes; caudal margins of segments narrowly but conspicuously pale yellow; subterminal segments more uniformly grayish brown; hypopygium extensively yellow. Male hypopygium with the caudal margin of tergite (Plate 5, fig. 57, 9*t*) conspicuously emarginate, the lobes relatively short, the entire emargination provided with abundant long black setæ that occur in several ranks throughout the entire extent; on ventral margin of tergite a conspicuous subrectangular lobe that is densely clothed with erect setulæ. Styli as shown. In *luteipennis* the lateral lobes of the tergite (Plate 5, fig. 58, 9*t*) are longer, with unusually long and dense dark setæ at apex and down the mesal edge, at base of emargination with these setæ reduced to a single row; median ventral lobe of tergite very weak and reduced, not or but little evident.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Sidemi, August 10, 1897 (*Jankovski*), No. 482. Allotopotype, female, with type. Paratopotypes, one of each sex, with type, No. 470.

Tipula mediolobata is most readily told from the closely allied *T. luteipennis* Meigen, of Europe, by the structure of the male hypopygium. There is no darkened cloud at the end of vein 2d A of wings, as in *moiwana* (Matsumura). The subgeneric position of members of the *luteipennis* group is uncertain, but I would believe that they might be found to pertain to the typical subgenus. If a separate subgeneric group is required, the name *Platytipula* Matsumura (1916) is available.

TIPULA DOCILIS sp. nov. Plate 1, fig. 22; Plate 5, fig. 59.

Belongs to the *marmorata* group; allied to *obsoleta;* mesonotal præscutum gray, with four brown stripes; antennal scape and pedicel yellow, the flagellum black; wing pattern nearly obsolete; male hypopygium with caudal margin of tergite bearing a U-shaped notch; basistyle not apically produced; eighth sternite without noticeable armature; inner dististyle a flattened, compressed, yellow blade, with a single slender subapical blackened beak.

Male.—Length, about 12 to 13 millimeters; wing, 12 to 13.5; antenna, about 3.2.

Female.—Length, about 14 millimeters; wing, 13.

Frontal prolongation of head brown; nasus conspicuous; palpi brownish black. Antennæ (male) of moderate length, if bent backward extending about to mid-distance between bases of wings and halteres; scape and pedicel yellow, flagellum black; verticils shorter than the segments. Head gray.

Mesonotal præscutum gray with four brown stripes; scutum gray, each lobe with two brown areas; posterior sclerites of notum gray, with indications of a capillary dark line. Pleura light gray; dorsopleural region yellow. Halteres yellow, the knobs dark brown with the apices a little brightened. Legs with the coxæ light gray; trochanters yellow; femora yellow, the tips narrowly dark brown, the amount subequal on all legs; tibiæ yellow, the tips very narrowly darkened; tarsi passing into black. Wings (Plate 1, fig. 22) subhyaline, the stigma pale brown; a scarcely evident darker pattern, arranged much as in *obsoleta,* most evident as a weak seam in cell M adjoining vein Cu; veins brown. Venation: R_{1+2} entire; veins M_1 and M_2 divergent, cell M_1 ample; cell 1st M_2 with cephalic face convex; M_{3+4} short.

Abdominal tergites yellow to brownish yellow, more or less darkened sublaterally; in some cases, including type, only the outer segments are darkened. Male hypopygium (Plate 5, fig. 59) relatively small in size; basistyle incomplete, its caudal portion not narrowed or produced. Ninth tergite, 9*t,* with the caudal margin bearing a U-shaped notch. Outer dististyle moderately flattened. Inner dististyle, *id,* a simple compressed yellow blade, with a small acute subterminal beak. Eighth sternite, 8*s,* with the caudal margin gently convex, but without any conspicuous armature of lobes or setæ; median area narrowly membranous.

Habitat.—Eastern Siberia (Kamchatka).

Holotype, male, Osernaja Village, mouth of Osernaja River, 160° 30′ east longitude, 57° north latitude, September 13, 1909 (*Dershavin*), No. 387. Allotopotype, a broken female, Great Javinsky, source of Osernaja River, Lake Kurilskoje, September 19, 1909, No. 402. Paratopotypes, 2 males, with types, Nos. 388, 390.

In its general appearance, the present fly is very similar to the European *Tipula obsoleta* Meigen, but is very distinct in the structure of the male hypopygium, notably the simple inner dististyle and unproduced eighth sternite.

TIPULA FIDELIS sp. nov. Plate 1, fig. 23; Plate 5, figs. 60, 61.

Belongs to the *marmorata* group, allied to *productella;* general coloration gray, the præscutum with three brown stripes, the broad median one entire; antennæ unusually long for a member of the group, if bent backward extending about to base of abdomen; wings with the pattern nearly obsolete; male hypopygium with the basistyle produced into a slender flattened lobe; eighth sternite with the caudal margin subtransverse, without lobes or hair brushes, excepting a sparse median group of long yellow setæ.

Male.—Length, about 12 millimeters; wing, 14; antenna, about 5.

Frontal prolongation of head obscure yellow, nasus distinct; palpi light brown, the outer segments darker. Antennæ (male) longer than usual in the group; scape and pedicel yellow, flagellum brownish black; verticils shorter than the segments. Head brownish gray.

Mesonotal præscutum gray, with three brown stripes, the median one darker, broad and entire; brown areas of scutal lobes poorly defined. Pleura gray, the dorsopleural membrane pale yellow. Halteres yellow, the knobs dark brown. Legs with the coxæ yellow, very sparsely dusted; trochanters yellow; femora yellow, the tips narrowly brownish black; tibiae yellow, the tips very narrowly darkened; basitarsi yellow, the tips and remainder of tarsi black. Wings (Plate 1, fig. 23) grayish subhyaline, with the usual pattern almost obsolete; stigma brown; much paler brown clouds on anterior cord; vague whitish areas beyond stigma, before cord and as a spot in outer end of cell M; veins brown. Venation: Outer medial veins not conspicuously arched or arcuated, as is common elsewhere in the group; m-cu a short distance before fork of M_{3+4}.

Abdominal tergites yellow, trivittate with brown, the lateral margins narrowly pale; on intermediate and outer segments the amount of brown increases, the outermost segments darkened; basal sternites yellow, the outer segments darker. Male hypopygium (Plate 5, fig. 60) with the basistyle, *b,* produced into a flattened blade, as in *productella.* Ninth tergite (Plate 5, fig. 61, 9*t*) with obtuse lateral lobes, the median area of tergite membranous. Inner dististyle a broadly compressed darkened blade, subcircular in outline; ventrad of this lies a flattened yellow lobe, dilated outwardly, provided with numerous setæ, some from enlarged bases. Eighth sternite (Plate 5, fig. 60) without lobes on caudal margin, the membranous median portion nearly transverse, with a sparse brush of long yellow setæ.

Habitat.—Eastern Siberia (Jakutsk).

Holotype, male, between Ajan and Nelkan, sources of Ignitjana River, August, 1903 (*Popoff*), No. 445.

Tipula fidelis is quite distinct from the other regional members of the *marmorata* group. The unusually long antennæ of the male, presence of only three præscutal stripes, and the conspicuously produced basistyle of the male hypopygium, all readily serve to distinguish this fly. The produced basistyle is much as it is in *T. productella* Alexander (Boreal North America), but the unmodified eighth sternite and the entire median præscutal stripe are very different.

TIPULA CUPIDA sp. nov. Plate 1, fig. 24; Plate 5, figs. 62, 63.

Belongs to the *marmorata* group, allied to *vafra* and *fragilina;* male hypopygium large, the lateral angles of ninth tergite extended laterad and ventrad into slender blackened points; eighth sternite large, the caudal portion bilobed by a deep incision, the lobes conspicuously setiferous.

Male.—Length, 10.5 to 11.5 millimeters; wing, 12.5 to 13.

Frontal prolongation of head brown; nasus distinct; palpi brownish black. Antennæ with scape and pedicel yellow, flagellum black. Head light gray.

Mesonotal præscutum gray, with four brown stripes, the anterior ends of the intermediate pair suffused with gray; posterior sclerites of notum gray, each lobe of scutum conspicuously variegated with dark brown. Pleura light gray, variegated with darker gray. Legs with the coxæ light gray; trochanters yellow; femora yellow, the tips narrowly infuscated; tibiæ obscure yellow, the tips very narrowly darkened; tarsi passing into brownish black. Wings (Plate 1, fig. 24) pale brown, variegated with darker brown and white areas, the pattern arranged as in the group; stigma, a confluent seam on anterior cord, a seam along vein Cu, and a cloud at apex of latter darker brown; two slightly less intense brown areas in cell M adjoining vein Cu; the whitish areas lie before and beyond stigma, in base of cell 1st M_2, at near midlength of cell M, and in cells Cu and 1st A; veins brown. Venation: Outer medial elements conspicuously arcuated, as common in the group.

Abdomen brown, the outer segments darker brown, the caudal margins of the segments ringed with pale. Male hypopygium (Plate 5, fig. 62) relatively large and conspicuous. Ninth tergite, *9t*, with a broad V-shaped notch, the lateral angles extended laterad and ventrad into slender blackened points. Outer dististyle, *od*, with the blackened area at base less spinous than in *vafra*. Inner dististyle (Plate 5, fig. 63, *id*) flattened, the extreme apex of beak minutely bifid. Eighth sternite, *8s*, large and sheathing, the margin with two stout lobes that are clothed with long conspicuous setæ. Gonapophyses appearing as slender, delicately setiferous blades that gradually narrow to tips.

Habitat.—Eastern Siberia (Kamchatka).

Holotype, male, foot of Volcano Shiveluch, 162° 30′ east longitude, 56° 40′ north latitude, August 20, 1909 (*Protopopoff*), No. 420. Paratype, male, Lake Kurilskoje, September 28, 1909 (*Dershavin*), No. 405. Expedition Rjabushinsky Brothers.

The present fly is very closely allied to *T. vafra* Riedel (northern Europe) and somewhat more distantly to *T. fragilina* Alexander (northwestern North America), differing chiefly in slight features of the male hypopygium. *Tipula vafra* is somewhat larger, with a paler wing pattern; basal flange of outer dististyle produced into a distinct blackened tooth; inner dististyle with the blade wider, the apical beak slightly longer; lobes of eighth sternite shorter and wider, appearing more flattened.

TIPULA GYNAPTERA Alexander.

Tipula gynaptera ALEXANDER, Journ. New York Ent. Soc. 24 (1918) 72–73.

The unique type, a female, was collected at Plover Bay, northeastern Siberia, July 11, 1899, by Dr. William H. Dall. A number of additional specimens from this same general region are now available and further comparisons with the nearest described ally, *Tipula whitneyi* Alexander (Pribilof Islands) may be made.

The comparisons made at the time of original definition, of larger and more protuberant eyes and somewhat more elongate antennæ in the female of *whitneyi*, hold in the present series and moreover apply to the male sex as well. The longer, more stenopterous wings of the male of the present fly are likewise conspicuously different from the wings of *whitneyi*.

Fifteen additional specimens from Unden and Markovo, Chuckchi-land, Gulf of Anadyr, 175° 30′ east longitude, 64° 30′ north latitude, collected in 1898 by Gondatti. One of these is described herewith as allotype.

Allotype, male, length, 11 to 12 millimeters; wing, 4 to 5.

Antennæ black throughout; flagellar segments short, strongly constricted at near midlength. Præscutum with a median dark gray stripe that is narrowly bordered behind by more brownish, gray, the lateral stripes obsolete or nearly so. Wings reduced, stenopterous, exceeding twice the length of the halteres and much longer than the antennæ. Male hypopygium without a median tooth at base of tergal notch. Inner dististyle with the lower lobe very broad.

Allotype, male, Anadyr Region, Chuckchi-land (*Gondatti*), No. 573.

In some of the other specimens, the pedicel of the antenna is obscure yellow.

These two flies, *gynaptera* and *whitneyi*, with the wings greatly reduced in both sexes, belong to what I had earlier called the *cineracea* group, including, besides the above, five species that are fully winged in both sexes: *T. cineracea* Coquillett, *T. crawfordi* Alexander, *T. katmaiensis* Alexander, *T. kirbyana* Alexander, and *T. malaisei* Alexander, all species occurring in Boreal North America and Asia, on both sides of Bering Straits, including Alaska, Wrangel Island, and Kamchatka. All members of the group agree in their small size, conspicuous lack of a nasus, simple male hypopygium, and other characters. The only species with evidently patterned wings is *crawfordi*. The hypopygia of the various species do not appear to present many characters, the relative length of the antennæ and the degree of constriction of the flagellar segments appearing more satisfactory.

TIPULA BLASTOPTERA sp. nov. Plate 5, fig. 64.

Female with wings greatly reduced in size; general coloration brown, the præscutum depressed; frontal prolongation of head short and stout, in alignment with the anterior vertex; antennæ 12-segmented, the outer segments short and crowded; abdomen black, the valves of ovipositor elongate, smooth.

Female.—Length, about 8.5 millimeters; wing, 0.7; antenna, 1.3.

Frontal prolongation of head brownish gray, short and stout, almost as in *Nephrotoma*, the prolongation in alignment with the anterior vertex; nasus short and stout; palpi brownish black. Antennæ (Plate 5, fig. 64) short, subequal in length to head (including prolongation); scape dark brown, pedicel obscure yellow; basal flagellar segments brighter brown than the outer ones; antennæ 12-segmented, the outer four flagellar segments short and crowded; basal flagellar segments short-cylindrical, the verticils exceeding the segments. Head brownish gray.

Mesonotum dark grayish brown, without distinct stripes; præscutal interspaces indicated by small yellow setæ; præscutum depressed, scutellum large. Pleura light brown. Halteres pale, reduced in size, bent, knobs poorly developed, darkened. Wings reduced to short scales that are about as long as the fore coxæ and much shorter than antennæ; wing venation reduced, the outer radial veins best indicated by rows of strong trichia; costal trichia reduced to two or three on basal half.

Abdomen chiefly black, the caudal margins of the intermediate segments very narrowly brightened. Ovipositor with the shield chestnut black; all valves elongate, with smooth margins.

Habitat.—Eastern Siberia (Ussuri).

Holotype, female, Sitza Station, Suchan District, June 15, 1927 (*Stackelberg*), No. 738.

In the female sex, the great reduction of the wings should make the identification of this species a very simple matter. No regional species of *Tipula* is known to me in the male sex that could possibly be associated with the present fly. The short frontal prolongation of the head is much as in *Nephrotoma*. It may be fairly assumed that this region of the body would be similar in the male and, if so, the alignment of the prolongation with the remainder of the front and the anterior vertex would be very characteristic, reminding one of certain Australian Tipulinæ, allied to *Clytocosmus* Skuse. European species of *Tipula* with the wings of the female greatly reduced include *T. autumnalis* Loew, *T. carinifrons* Holmgren, *T. gimmerthali* Lackschewitz, *T. pagana* Meigen, and two species of the subgenus *Vestiplex* Bezzi, [*T.* (*V.*) *cisalpina* Riedel and *T.* (*V.*) *hemapterandra* Bezzi], in all of which the wings, although reduced, are very much larger than in the present fly and show the venation clearly but distorted. Those species with greatest wing reduction (*autumnalis, gimmerthali, pagana*) are characteristic autumnal species, while the present fly is adult in spring.

ILLUSTRATIONS

[Legend: *a*, Ædeagus; *b*, basistyle; *d*, dististyle; *g*, gonapophysis; *id*, inner dististyle; *o*, cercus of ovipositor; *od*, outer dististyle; *p*, phallosome; *s*, sternite; *t*, tergite.]

PLATE 1

FIG. 1. *Tipula* (*Vestiplex*) *excisoides* sp. nov., venation.
2. *Tipula* (*Vestiplex*) *kamchatkana* sp. nov., venation.
3. *Tipula* (*Vestiplex*) *pallitergata* sp. nov., venation.
4. *Tipula* (*Vestiplex*) *immunda* sp. nov., venation.
5. *Tipula* (*Vestiplex*) *transbaikalica* sp. nov., venation.
6. *Tipula* (*Vestiplex*) *tchukchi* sp. nov., venation.
7. *Tipula* (*Arctotipula*) *hirtitergata* sp. nov., venation.
8. *Tipula* (*Arctotipula*) *gavronskii* sp. nov., venation.
9. *Tipula* (*Arctotipula*) *popoffi* sp. nov., venation.
10. *Tipula* (*Arctotipula*) *tundrensis* sp. nov., venation.
11. *Tipula* (*Lunatipula*) *polypogon* sp. nov., venation.
12. *Tipula* (*Lunatipula*) *lamentaria* sp. nov., venation.
13. *Tipula* (*Lunatipula*) *lundströmiana* sp. nov., venation
14. *Tipula* (*Lunatipula*) *flaccida* sp. nov., venation.
15. *Tipula* (*Lunatipula*) *dershavini* sp. nov., venation.
16. *Tipula* (*Lunatipula*) *lætibasis* sp. nov., venation.
17. *Tipula* (*Lunatipula*) *gondattii* sp. nov., venation.
18. *Tipula* (*Lunatipula*) *derbecki* sp. nov., venation.
19. *Tipula* (*Lunatipula*) *chernavini* sp. nov., venation.
20. *Tipula* (*Lunatipula*) *mesacantha* sp. nov., venation.
21. *Tipula mediolobata* sp. nov., venation.
22. *Tipula docilis* sp. nov., venation.
23. *Tipula fidelis* sp. nov., venation.
24. *Tipula cupida* sp. nov., venation.

PLATE 2

FIG. 25. *Tipula* (*Vestiplex*) *excisoides* sp. nov., male hypopygium, details.
26. *Tipula* (*Vestiplex*) *excisa* Schummel, male hypopygium, details.
27. *Tipula* (*Vestiplex*) *kamchatkana* sp. nov., male hypopygium, details.
28. *Tipula* (*Vestiplex*) *pallitergata* sp. nov., male hypopygium, details.
29. *Tipula* (*Vestiplex*) *immunda* sp. nov., male hypopygium, details.
30. *Tipula* (*Vestiplex*) *transbaikalica* sp. nov., male hypopygium, details.
31. *Tipula* (*Vestiplex*) *subcentralis* Alexander, male hypopygium, details.
32. *Tipula* (*Vestiplex*) *tchukchi* sp. nov., male hypopygium, details.
33. *Tipula* (*Vestiplex*) *tchukchi* sp. nov., male hypopygium, details.

PLATE 3

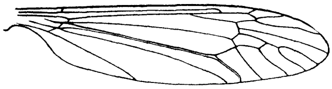
FIG. 34. *Tipula* (*Arctotipula*) *hirtitergata* sp. nov., male hypopygium, details.
35. *Tipula* (*Arctotipula*) *gavronskii* sp. nov., ovipositor.
36. *Tipula* (*Arctotipula*) *popoffi* sp. nov., ovipositor.
37. *Tipula* (*Arctotipula*) *tundrensis* sp. nov., male hypopygium, details.
38. *Tipula* (*Arctotipula*) *tundrensis* sp. nov., male hypopygium, detail.
39. *Tipula* (*Lunatipula*) *polypogon* sp. nov., male hypopygium, details.
40. *Tipula* (*Lunatipula*) *polypogon* sp. nov., male hypopygium, details.
41. *Tipula* (*Lunatipula*) *lamentaria* sp. nov., male hypopygium, details.
42. *Tipula* (*Lunatipula*) *lamentaria* sp. nov., male hypopygium, details.

PLATE 4

FIG. 43. *Tipula* (*Lunatipula*) *lundströmiana* sp. nov., antenna, male, segments three to six.
44. *Tipula* (*Lunatipula*) *lundströmiana* sp. nov., male hypopygium, details.
45. *Tipula* (*Lunatipula*) *lundströmiana* sp. nov., male hypopygium, details.
46. *Tipula* (*Lunatipula*) *flaccida* sp. nov., antenna, male, segments three to six.
47. *Tipula* (*Lunatipula*) *flaccida* sp. nov., male hypopygium, details.
48. *Tipula* (*Lunatipula*) *flaccida* sp. nov., male hypopygium, details.
49. *Tipula* (*Lunatipula*) *dershavini* sp. nov., male hypopygium, details.
50. *Tipula* (*Lunatipula*) *lætibasis* sp. nov., male hypopygium, details.
51. *Tipula* (*Lunatipula*) *sachalinensis* Alexander, male hypopygium, details.
52. *Tipula* (*Lunatipula*) *gondattii* sp. nov., male hypopygium, details.
53. *Tipula* (*Lunatipula*) *gondattii* sp. nov., male hypopygium, details.

PLATE 5

FIG. 54. *Tipula* (*Lunatipula*) *derbecki* sp. nov., male hypopygium details.
55. *Tipula* (*Lunatipula*) *mesacantha* sp. nov., male hypopygium, details.
56. *Tipula* (*Lunatipula*) *mesacantha* sp. nov., male hypopygium, details.
57. *Tipula* *mediolobata* sp. nov., male hypopygium, details.
58. *Tipula* *luteipennis* Meigen, male hypopygium, details.
59. *Tipula* *docilis* sp. nov., male hypopygium, details.
60. *Tipula* *fidelis* sp. nov., male hypopygium, details.
61. *Tipula* *fidelis* sp. nov., male hypopygium, details.
62. *Tipula* *cupida* sp. nov., male hypopygium, details.
63. *Tipula* *cupida* sp. nov., male hypopygium, details.
64. *Tipula* *blastoptera* sp. nov., antenna, female.



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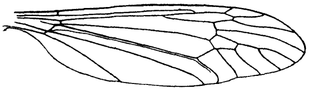

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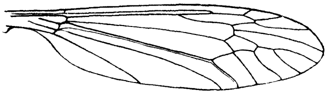

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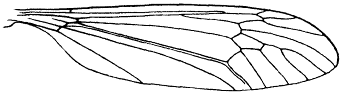

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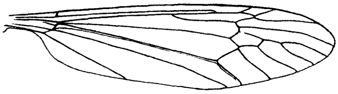

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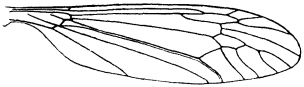

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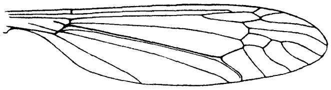

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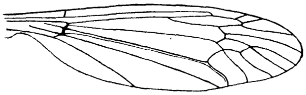

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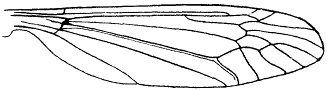

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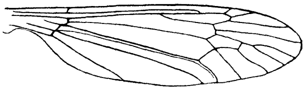

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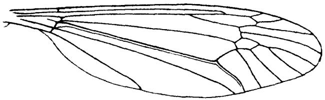

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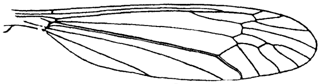

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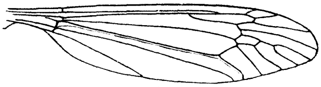

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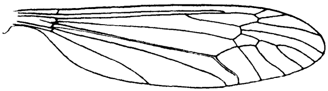

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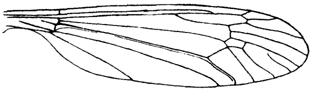

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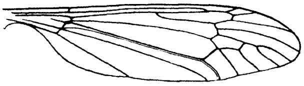

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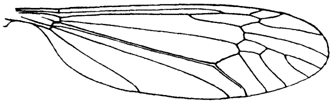

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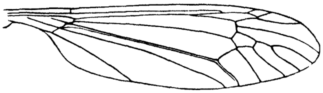

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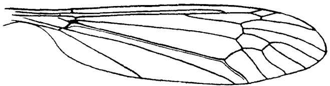

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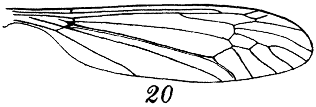

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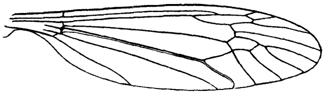

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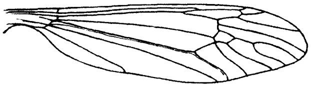

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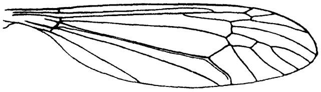

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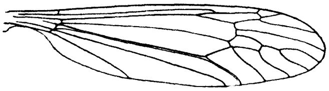

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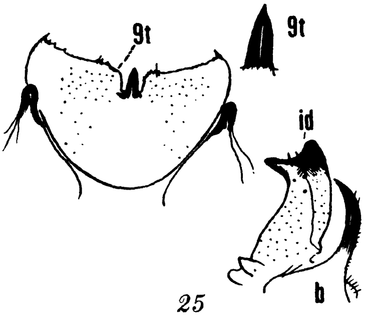
PLATE 1.



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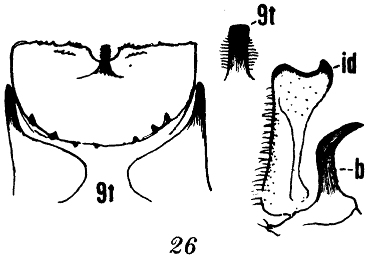

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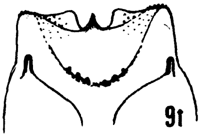

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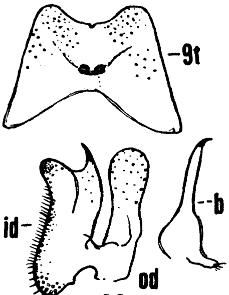

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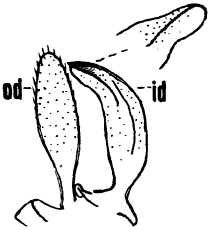

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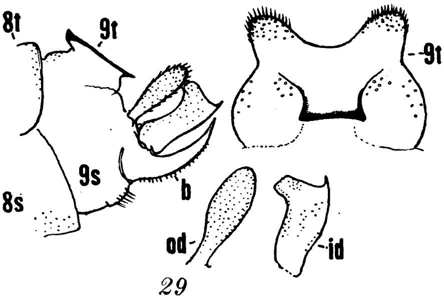

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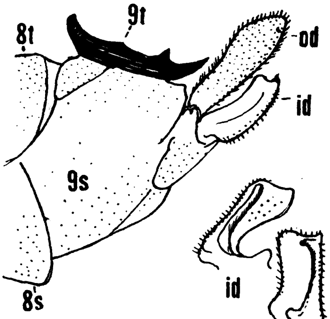

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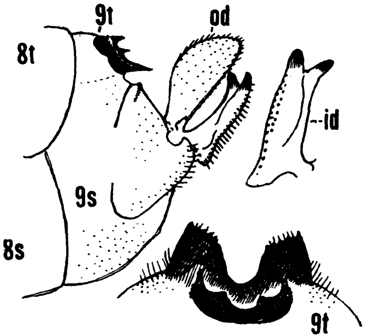

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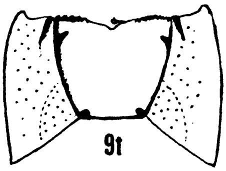

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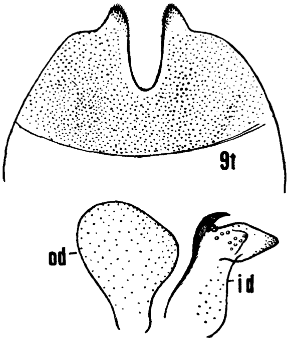

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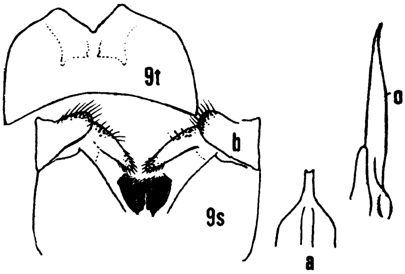

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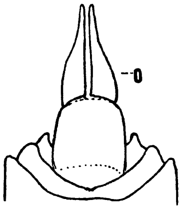

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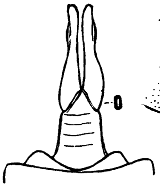

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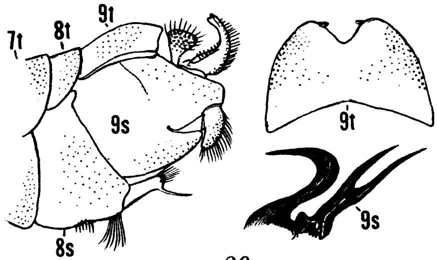

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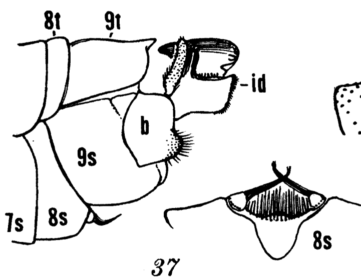

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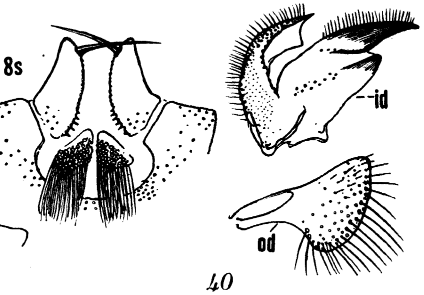

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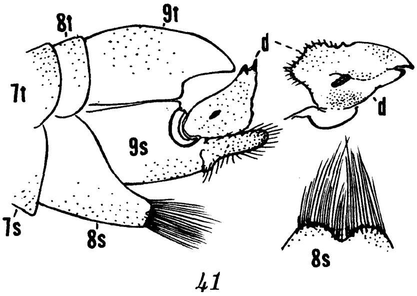

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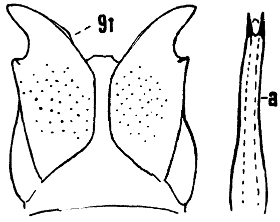

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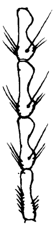

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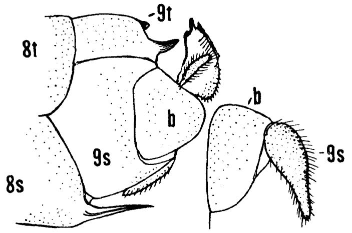

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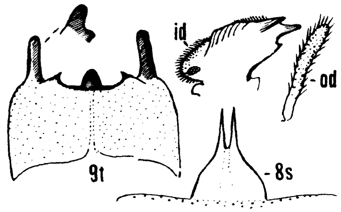

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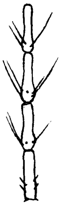

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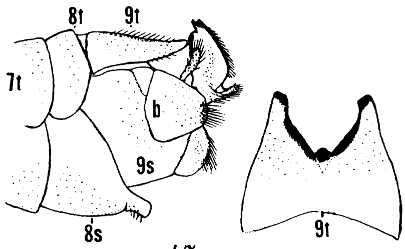

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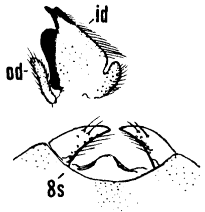

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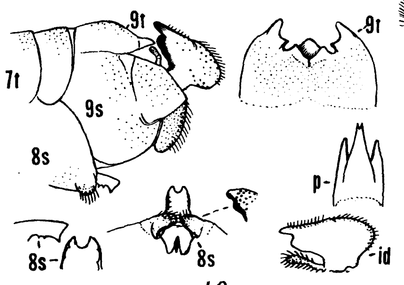

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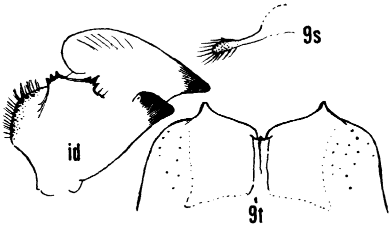

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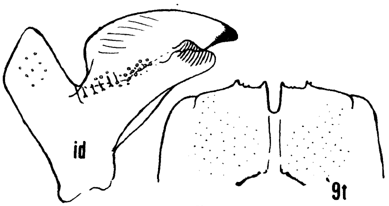

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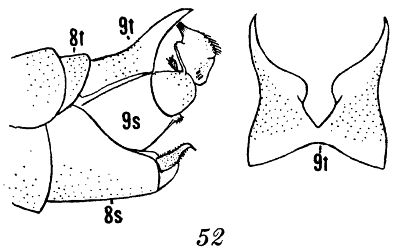

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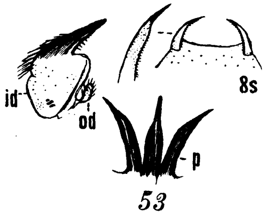

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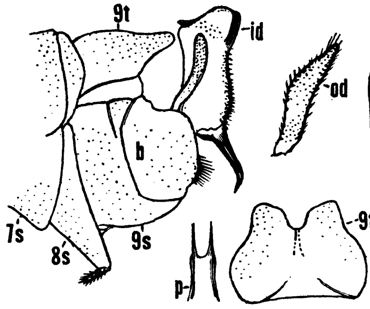
PLATE 4.

UNIV. OF MICH.



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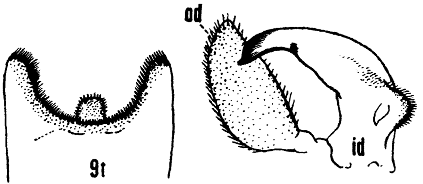

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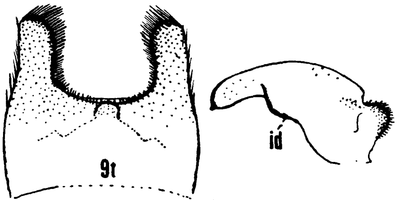

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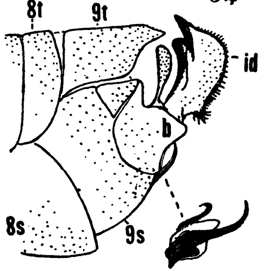

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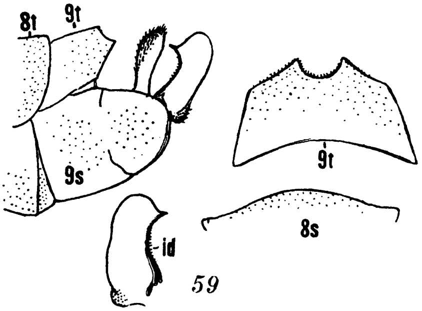

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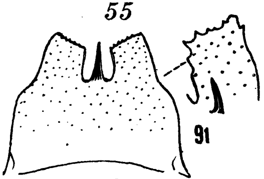

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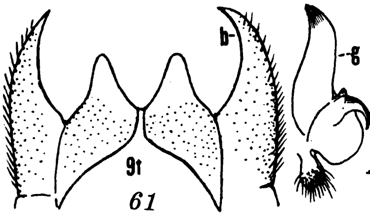

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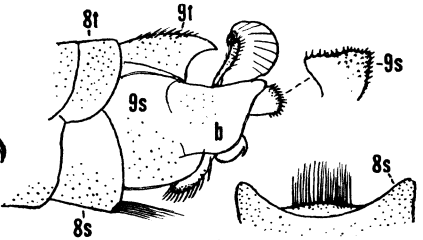

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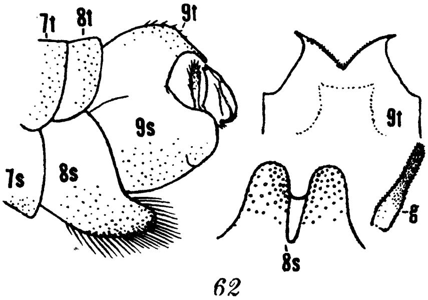

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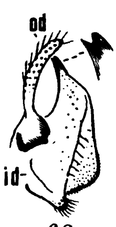

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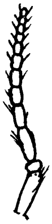

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PLATE 5.

NEW OR NOTEWORTHY PHILIPPINE ORCHIDS, IV

By OAKES AMES
Professor of Botany in Harvard University
and
EDUARDO QUISUMBING
Botanist, National Museum Division, Bureau of Science, Manila

SEVENTEEN PLATES

The present contribution is essentially similar to its predecessors.[1] It consists of descriptions of five new species and four new varieties. One previously described species, *Cymbidium dayanum,* is for the first time credited to the Archipelago. *Phalaenopsis Micholitzii, Aërides Jarckianum, Aërides quinquevulnerum* var. *album,* and *Phalaenopsis equestris* var. *leucotanthe,* which were known only from their original descriptions, were recently rediscovered. A few combinations and changes in nomenclature are hereby proposed; this is particularly true with the species belonging formerly to *Trichoglottis* which we now propose to transfer to *Stauropsis. Sarcochilus unguiculatus,* which was interpreted as a synonym of *S. pallidus,* is hereby validated and elevated once more to a specific rank. All the descriptions in the text have been prepared from living specimens, and all the illustrations were made by Messrs. F. Guerrero and J. M. Salazar, draftsmen of the National Museum Division, Bureau of Science. All the types of the new species and varieties have been deposited in the herbarium of the Bureau of Science, with the isotypes in the herbarium of the senior author. Available isotypes will be distributed to the herbarium of the New York Botanical Garden and to other herbaria.

Genus DENDROBIUM Swartz

DENDROBIUM ALICIAE sp. nov. Plate 1, figs. 1 and 2; Plate 4, figs. 1 to 9; Plate 8, fig. 1.

Aff. *Dendrobio acuminatissimo.* Caules numerosi, simplices, fasciculati, penduli, 98 ad 107 cm longi, 2 ad 2.5 mm in crassi-

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[1] Philip. Journ. Sci. 44 (1931) 369–383, 16 pls.; 47 (1932) 197–220, 29 pls.; 49 (1932) 483–504, 28 pls.

tudine, nitidi, teretes; internodia 1.5 ad 3.5 cm longa. Folia linearia, longe angustata, apice valde inaequalia, 9.5 ad 11.5 cm longa, 5 ad 5.5 mm lata, papyracea, vaginae foliorum arctae, glabrae. Racemi biflori; rhachis brevissima; pedunculus 1.3 ad 1.8 cm longus; bracteae oblongae, 7 ad 10 mm longae. Flores fugaces, caduci. Sepala lineari-lanceolata, in caudas longas filiformes tenerrimas extensa 3 ad 6 cm longa, basi 3.5 ad 5 mm lata; mentum sepalorum lateralium breve, obtusum, 4 ad 5.5 mm longum. Petala aequalia, 3 ad 5 cm longa, basi 2.5 ad 3 mm lata. Labellum manifeste trilobum, 10 ad 11 mm longum; lobi laterales oblique ovato-triangulares, obtusi, parte libera 2.25 ad 2.5 mm longa; lobus intermedius multo major, ovato-oblongus, 6 ad 7 mm longus, 2.5 ad 3 mm latus, supra conspicue densissime pilosus; discus per dimidium basale cum linea mediana incrassata. Gynostemium breve, circiter 4 mm longum; stelidia brevia, rotundata, levissime denticulata.

Stems numerous, simple, fascicled, pendulous, 98 to 107 cm long, 2 to 3.5 mm in diameter, smooth, terete; internodes 1.5 to 3.5 cm long. Leaves linear, narrowed to the tips, the apex unequal, 9.5 to 11.5 cm long, 5 to 5.5 mm wide, papery, the sheaths glabrous. Racemes two-flowered, rachis very short, the peduncles 1.3 to 1.8 cm long; bracts oblong, 7 to 10 mm long. Flowers fugaceous, ephemeral. Sepals linear-lanceolate, with very long slender prolongations, 3 to 6 cm long, 3.5 to 5 mm wide at the base; the mentum short, obtuse, 4 to 5.5 mm long. Petals similar to the sepals in form, 3 to 5 cm long, 2.5 to 3 mm wide. Labellum manifestly trilobed, 10 to 11 mm long; lateral lobes (free portion) obliquely ovate-triangular, obtuse, 2.25 to 2.5 mm long, covered with short papillose hairs; middle lobe much larger, ovate-oblong, 6 to 7 mm long, 2.5 to 3 mm wide, the upper surface densely and conspicuously pilose. Disc through the basal half with a very prominent central fleshy ridge. Column short, about 4 mm long, stelidia short, rounded, obscurely denticulate.

LUZON, Benguet Subprovince, Baguio, *Bur. Sci. 84618 Eduardo Quisumbing,* May 9, 1932. The type material was originally collected by Mrs. K. B. Day from Mount Santo Tomas, near Baguio. Living plants are now under cultivation in the gardens of Mrs. K. B. Day and Mrs. Colton in Baguio, and Mrs. Remedios C. Gonzales in Manila.

Sepals and petals are straw yellow [2] and spotted with carmine or oxblood red; the middle lobe of the labellum is empire yellow, covered on the upper surface with numerous white hairs, the lateral lobes are white and spotted with oxblood red.

The alliance of this species is doubtless with *Dendrobium acuminatissimum* (Blume) Lindl. which had been found but twice in the Philippines. It differs, however, conspicuously in the size and color of the flowers, and in the details of the labellum.

This species is dedicated to Mrs. K. B. Day who has graciously and kindly coöperated with the junior author in giving him free access to her collections of living orchids and is a testimonial to her interest in Philippine orchids.

DENDROBIUM PLICATILE Lindl. var. CONVOCARII var. nov. Plate 1, figs. 5 and 6; Plate 4, figs. 10 to 19; Plate 8, fig. 2.

Aff. *D. plicatili.* Caules 35 ad 65 cm longi, ramosi. Pseudobulbi parvi, monophylli. Folia sessilia, elliptica vel oblongo-elliptica, obtusa, 4 ad 6.5 cm longa, 2.5 ad 3 cm lata. Flores odoratissimi, singuli, fugacei, parvi, 2.8 ad 3 cm lati. Sepala oblongo-lanceolata, subacuta, 1.7 ad 1.9 cm longa, 6 ad 6.25 mm lata, mentum conicum, obtusum, circiter 5 mm longum formantia. Petala anguste oblonga, subacuta, 1.4 ad 1.5 cm longa, 3 and 3.5 mm lata. Labellum 1.6 ad 1.9 cm longum, basi cuneata; lobi laterales oblique triangulari-ovati, apice rotundati, parte libera 3 ad 4 mm longa, lobus intermedius subquadrato-flabellatus, retusus, margine valde undulato et lobulato; carinae usque supra medium 3, cum mediana obscura, deinde elevatulae et undulatae. Gynostemium brevissimum.

Rhizomes creeping, 6 to 8 mm in diameter. Stems rigid, suberect, smooth, shining and polished, jointed, 35 to 65 cm long, 4 to 6 mm in diameter, branching. Pseudobulbs monophyllous, shining; the leaflets ones usually ellipsoid or fusiform, up to 6 cm long; the leaf-bearing ones smaller, narrowly oblong-cylindric or oblong-obconic, 1.5 to 2.5 cm long. Leaves terminal, sessile, solitary, elliptic or oblong-elliptic, obtuse, 4 to 6.5 cm long, 2.5 to 3 cm wide. Flowers fragrant, solitary, axillary at the summit of apical pseudobulbs or at nodes at the apex of very short slender branches above the pseudobulbs, fugaceous,

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[2] The color terms used are mostly from Ridgway's Color Standards and Color Nomenclature (1912).

2.8 to 3 cm across. Sepals oblong-lanceolate, subacute, 1.7 to 1.9 cm long, 6 to 6.25 cm wide, lateral ones oblique, forming a conical obtuse straight spur about 5 mm long. Labellum 3-lobed, 1.6 to 1.9 cm long, the base cuneate, decurved about in the middle; lateral lobes obliquely triangular-ovate, rounded at the apex, the free portion 3 to 4 mm long; middle lobe about 10 mm long, 14 mm wide, subquadrate-flabelliform, apex retuse; carinae 3, the middle line extending from the base of the labellum to the apex, the lateral ones prominently elevated and crisped in the middle particularly at the isthmus, the keels 1 to 1.5 mm high. Column very short.

LUZON, Manila, Bureau of Science orchid house, *Bur. Sci. 84713 Eduardo Quisumbing,* September 8, 1931.

The living plants were originally collected by Messrs. Maximo Ramos and Pascual Convocar in Dinagat Island, Surigao Province, Mindanao, on medium-sized trees near the seashore, in June, 1931, but now grow on adobe stone walls in the Bureau of Science orchid house.

Petals, lip, and column white, spotted with violet-carmine. Sepals white, suffused with massicot yellow at the base and spotted with violet-carmine. Spur massicot yellow and minutely dotted with pomegranate purple.

This form is apparently distinguished from the variable *Dendrobium plicatile* Lindl. by the smaller leaves, pseudobulbs, and flowers and by the lack of an elongate base of the lip. This variety is dedicated to Mr. Pascual Convocar, a botanical collector of the Bureau of Science, who discovered these plants perched on a tree.

DENDROBIUM IRAYENSE sp. nov. Plate 3, figs. 5 and 6; Plate 4, figs. 20 to 28; Plate 9, fig. 1.

Caules fasciculati, simplices, 30 ad 95 cm longi, penduli, multiarticulati, teretes; internodia 1.5 ad 3 cm longa, fibris vaginarum dejectarum vestita; nodi incrassati. Folia lineari-lanceolata, acuminata, acuta, submembranacea, 7.5 ad 9 cm longa, 1.4 to 1.6 cm lata; vaginae foliorum subcompressae, apice paulum ringentes. Racemi abbreviati, laxe 4- ad 8-flori, in caulibus defoliatis; bracteae sub anthesi scariosae, lanceolatae, acutae, 1.5 ad 2.5 mm longae. Flores purpurei, 1.4 ad 1.8 cm lati. Sepala lateralia ovata, acuta, 9 ad 10 mm longa, circiter 5.5 mm lata, 7-nervia, in mentum subaequilongum, obtusum producta. Sepalum dorsale erectum, ovato-lanceolatum, subacutum, 9 ad 9.5 mm longum, 4.5 ad 5 mm latum, 5-nervium. Petala lanceolato-elliptica, acuta, 8.5 ad 9.5 mm longa, 4 ad

4.5 mm lata, margine integra, 5-nervia. Labellum simplex, oblanceolatum, e basi sensim attenuatum, cucullatum, unguiculatum, subacutum, 13.5 ad 14 mm longum, callo basali hippocrepiformi. Columna brevis; clinandrium tridentatum, dentibus lateralibus rotundatis, dente medio tenui.

Stems fascicled, unbranched, 30 to 95 cm long, 8 to 15 mm in diameter, pendulous, terete, with swollen nodes; internodes 1.5 to 3 cm long. Leaves linear-lanceolate, acuminate, acute, submembranaceous, 7.5 to 9 cm long, 1.4 to 1.6 cm wide, the sheaths subcompressed. Racemes short, laxly 4- to 8-flowered, on defoliated stems. Flowers purple, 1.4 to 1.8 cm across, odorless; bracts pale purple, lanceolate, acute, 1.5 to 2.5 mm long. Pedicellate ovary slender, 10 to 14 mm long. Lateral sepals, ovate, acute, 9 to 10 mm long, about 5.5 mm wide at the base, 7-nerved; mentum subequally long, obtuse, retuse at the very tip. Dorsal sepal erect, ovate-lanceolate, subacute, 9 to 9.5 mm long, 4.5 to 5 mm wide, 5-nerved. Petals lanceolate-elliptic, acute, 8.5 to 9.5 mm long, 4 to 4.5 mm wide, the margins entire, 5-nerved. Labellum simple, oblanceolate, narrowed at the base, cucullate, unguiculate, subacute, 13.5 to 14 mm long, 5 to 5.5 mm wide near the apex, with a horseshoe-shaped callus at the base. Column short, about 2 mm long; stelidia erect, the lateral ones rounded, the median slender acute.

LUZON, Manila, Bureau of Science orchid house, *Bur. Sci. 84714 Quisumbing,* February 5, 1932.

The living plants were originally collected by the late Mr. Maximo Ramos, collector of the Bureau of Science, on Mount Iraya, Batan Island, north of Luzon.

The flowers are mallow purple or phlox purple, the nerves on sepals and petals and the lines on the labellum true purple; anther apricot yellow.

Dendrobium irayense is allied to *Dendrobium victoriae-reginae* Loher, but differs in its much smaller flowers and in the short lateral sepals.

DENDROBIUM YEAGERI sp. nov. Plate 3, figs. 7 and 8; Plate 4, figs. 29 to 37; Plate 9, fig. 2.

Caules fasciculati, 25 ad 50 cm longi, pauci ramosi, penduli; internodia ad basim leviter incrassata, 1.2 ad 2 cm longa. Folia lanceolata, acuta, 4.5 ad 10.5 cm longa, 1.3 ad 2.3 cm lata, nervosa, papyracea; vaginae foliorum subcompressae, apice paulum ringentes. Racemi pauciflori (2- ad 6-flori); bracteae oblongae, obtusae, usque ad 6 mm longae, membranaceae; ovarium pedicellatum tenerum, 1.5 ad 1.6 cm longum. Sepala lateralia lanceolato-oblonga, obtusa, circiter 1.9 cm longa, 7 ad 9 mm lata, 7-nervia, mentum obtusum, 9 ad 10 mm longum formantia. Sepalum dorsale oblongo-lanceolatum, subobtusum, 1.8 ad 1.9 cm longum, 7.5 ad 8 mm latum, 7-nervium. Petala anguste oblonga vel oblongo-elliptica, subobtusa, circiter 1.9 cm longa, 5.5 ad 7 mm lata, 5-nervia. Labellum simplex, oblanceolato-oblongum, e basi sensim dilatatum et antice expansum, apice rotundatum, 2.2 ad 2.5 cm longum, 9 ad 10 mm latum, lineae elevatulae nullae. Gynostemium perbreve, carnosum, circiter 5 mm longum, in pedem extensum; stelidia erecta, lateralia rotundata, stelidium medium acutum, 1 ad 1.25 mm longa. Capsula ellipsoidea, 2.4 ad 2.5 cm longa, 1.3 ad 1.4 cm in crassitudine. Flores basi purpureo-violacei, apice pallidiores.

Stems fascicled, slender, pendulous, 25 to 50 cm long; branches few, jointed, nodes greatly swollen, internodes 1.2 to 2 cm long. Leaves lanceolate, acute, 4.5 to 10.5 cm long, 1.3 to 2.3 cm wide, papyraceous and nervose when dried, leaf sheaths expanded above. Racemes few-flowered (2- to 6-flowered); bracts oblong, obtuse, up to 6 mm long, membranaceous. Flowers odorless, showy; pedicellate ovary slender, 1.5 to 1.6 cm long. Lateral sepals lanceolate-oblong, obtuse, about 1.9 cm long, 7 to 9 mm wide, 7-nerved, forming an obtuse mentum, 9 to 10 mm long. Dorsal sepal oblong-lanceolate, subobtuse, 1.8 to 1.9 cm long, 7.5 to 8 mm wide, 7-nerved. Petals narrowly oblong or oblong-elliptic, subobtuse, about 1.9 cm long, 5.5 to 7 mm wide, 5-nerved. Labellum simple, oblanceolate-oblong, gradually dilated from the base, expanded at the apex, broadly and bluntly apiculate, 2.2 to 2.5 cm long, 9 to 10 mm wide at the widest portion near the apex, devoid of any raised lines or calli. Column short, stout, about 5 mm long, extended into a foot; lateral arms erect, rounded, middle one narrow and acute, 1 to 1.25 mm long. Capsules ellipsoid, 2.4 to 2.5 cm long, 1.3 to 1.4 cm in diameter.

LUZON, Benguet Subprovince, Mount Pauai, *Bur. Sci. 85567 Eduardo Quisumbing,* May 9, 1932.

The living specimens were purchased from Igorot peddlers at Gate 52, Mountain Road, and were claimed to have originated in the hardwood forests of Mount Pauai.

The sepals and petals are pale lavender-violet or rose-purple at the tips, gradually increasing in intensity of color to the base which is Chinese violet or magenta, with the nerves of darker purple (Matthews' purple); labellum lavender-violet or pale rose-purple at the tip, darker at the base, bright violet-purple;

spur or mentum very bright violet-purple; pedicellate ovary aster purple; the column violet-purple, with white arms and anther.

Dendrobium Yeageri is closely allied to *Dendrobium victoriae-reginae* Loher, but may be readily separated by the reverse distribution of color in the flowers and the entirely smooth ecarinate lip.

This species is dedicated to Dr. C. H. Yeager, of the Rockefeller Foundation in Manila, who accompanied the junior author and Dr. W. H. Brown, former director of the Bureau of Science, on a trip to the Mountain Province in May, 1932.

Genus BULBOPHYLLUM Thouars

BULBOPHYLLUM SURIGAENSE sp. nov. Plate 1, figs. 3 and 4; Plate 5, figs. 1 to 9; Plate 10, figs. 1 and 2.

Radices fibratae, numerosae. Rhizoma repens. Pseudobulbi monophylli, cylindracei vel semifusiformes, 2.5 ad 3.2 cm longi, usque ad 5 cm distantia. Folia valde coriacea, rigida, ad apicem rotundata, ad basim attenuata, oblonga vel elliptico-oblonga, 5 ad 8.5 cm longa, 2 ad 2.8 cm lata, breviter petiolata. Scapus folio longior, 12 ad 14.5 cm longus; racemus recurvatus, 3 ad 3.5 cm longus, bracteis 5 vel 6 vaginantibus. Flores albidi, 2.5 ad 3.2 cm longi, in racemo perdenso dispositi. Bracteae inflorescentiae lineari-lanceolatae, acutae, cucullatae, 6 ad 10 mm longae. Pedicelli graciles. Sepala lateralia lanceolato-linearia, in apicem filiformem elongatum, obtusa, 5-nervia sensim extensa, primum connata, deinde libera, patentia, 3 ad 3.2 cm longa, glabra, prope basim ciliata. Sepalum dorsale ovatum, cucullatum, circiter 7 mm longum, 2.5 mm latum, 5-nervium, margine fimbriato. Petala triangulari-lanceolata, leviter falcata, acuminata, circiter 3.75 ad 4 mm longa, 3-nervia, margine fimbriato. Labellum minutum, anguste triangulare, acuminatum, acutum, recurvatum, ad basim cordatum, glabrum, 2.5 ad 3 mm longum, 1.5 mm latum, bilamellatum. Gynostemium brevissimum, ad apicem bicuspidatum, in pedem arcuatum extensum.

Roots numerous, fibrous, 0.75 to 1.25 mm in diameter. Rhizomes creeping, stout and woody. Pseudobulbs cylindrical or semifusiform, monophyllous, 2.5 to 3.2 cm long, strongly ridged, up to 5 cm apart, the young pseudobulbs clothed and almost covered with membranaceous, brown sheaths. Leaves oblong or elliptic-oblong, dark green, very leathery, firm and rigid, petiolate, bilobed at the rounded apex, cuneate at the base, 5 to 8.5 cm long, 2 to 2.8 cm wide; petioles 5 to 8 mm long. Scapes much longer than the leaves, 12 to 14.5 cm long including the erect peduncles; the racemes abbreviated, recurved or pendulous, 3 to 3.5 cm long. Sheaths infundibuliform, acute, 8 to 15 mm long, marguerite yellow with the tips greenish. Flowers odorless, crowded, 2.5 to 3.2 cm long. Pedicellate ovary very short, slender, greenish, 2 to 2.5 mm long. Floral bracts deep sea-foam green, linear-lanceolate, acute, cucullate, 6 to 10 mm long. Lateral sepals lanceolate-linear, with greatly elongated filiform tips, obtuse, 3 to 3.2 cm long, 5-nerved, white with marguerite yellow tips, minutely ciliate at the margins near the base, 5-nerved, at first connate, becoming free, parallel. Dorsal sepal ovate, acute, cucullate, about 7 mm long, 2.5 mm wide, 5-nerved, membranaceous, fimbriate on the margins. Petals narrowly triangular-lanceolate, slightly falcate, about 3.75 to 4 mm long, 1.25 mm wide at the base, ciliate on the margins, 3-nerved. Labellum minute, narrowly triangular, acuminate, acute, recurved, cordate at the base, glabrous, about 2.5 to 3 mm long, 1.5 mm wide, primuline yellow in color, with 2 ridges or keels running from the base to the tip. The column very short, white, about 1.5 mm long, bicuspidate at the apex, extended into an arcuate foot. Anther ovoid, obtuse, primuline yellow in color.

LUZON, Manila, Bureau of Science orchid house, *Bur. Sci. 84715 Eduardo Quisumbing*, September 11, 1931.

The living specimens were collected at Surigao, Surigao Province, Mindanao, by the botanical collectors, Messrs. Maximo Ramos and Pascual Convocar.

Among Philippine orchids, this species differs from *Bulbophyllum Loherianum* (Kränzl.) Ames in the much larger flowers and dissimilar lateral sepals and from *B. zamboangense* Ames in the awnless dorsal sepal and petals. It is vegetatively very similar to *B. medusae* Reichb. f.

Genus CYMBIDIUM Swartz

CYMBIDIUM DAYANUM Reichb. f. Plate 1, figs. 7 and 8; Plate 5, figs. 10 to 17; Plate 11, fig. 1.

Cymbidium dayanum REICHB. f. in Gard. Chron. (1869) 710: Williams' Orch. Grow. Man. ed. 7 (1894) 218; RIDL. Fl. Mal. Penin. 4 (1924) 146; Sanders' Orch. Guide (1927) 138.

Cymbidium acutum RIDL. in Journ. Linn. Soc. 32 (1896) 334; Mat. Fl. Mal. Penin. 1 (1907) 140; SCHLTR. Die Orchideen (1927) 355.

Cymbidium simonsianum KING and PRANTL. in Journ. As. Soc. Beng. 64, pt. 2 (1895) 338, in Ann. Roy. Bot. Gard. Calc. 8 (Orch. Sik.-Himal.) (1898) 188, *t. 250.*

The original description reads as follows:

> *Cymbidium Dayanum*, sp. n.
>
> Foliis longissimis (4 pedalibus), angustis (vix quartam pollicis latis) coriaceo-pergameneis apice nunc inaequali altero latere acutis, nunc aequaliter bidentatis, inferne suberosis; racemo plurifloro; vaginis scariosis acutis basi vaginato; rhachi angulata, bracteis triangulis acuminatis ovariis pedicellatis multo brevioribus, mento subevanido; flore carnosiusculo; sepalis linearibus acuminatis; petalis sublatioribus brevioribus, labello medio trifido, laciniis lateralibus semiovatis, acutangulis, lacinia media oblongo-triangula acuminata; carinis geminis parallelis approximatis velutinis, usque ad basin laciniarum lateralium altioribus, dein humilibus, ante apicem confluentibus.

Plant epiphytic, erect, stemless. Leaves 5 or 6, tufted, subcoriaceous, pale green, elongate linear, sessile, channelled at the base, acute and suboblique at the apex, 76.5 to 78.5 cm long, 1.1 to 1.4 cm wide. Racemes erect, about 24 cm long; peduncle about 11 cm long; sheaths at the base three or more, imbricated, 1 to 7 cm long, acute, pinkish vinaceous, the lowermost one nearly white. Pedicellate ovary 1.5 to 3 cm long. Flowers fragrant, about 10, 3.5 to 4.5 cm across; bracts triangular, acute, cucullate, 5 to 8 mm long. Lateral sepals spreading, elliptic-lanceolate or oblanceolate, acute and slightly subfalcate, 2.6 to 2.7 cm long, 7 to 8 mm wide. Dorsal sepal erect, elliptic-lanceolate or oblanceolate, acute, 2.8 to 2.9 cm long, 7 to 7.5 mm wide. Petals smaller than the sepals, connivent around the column, narrowly elliptic-oblong, acute, apiculate, 2.1 to 2.2 cm long, about 6 mm wide. Labellum 3-lobed, 2 to 2.2 cm long; lateral lobes broadly obtuse, free portion 3 to 3.5 mm long; middle lobe ovate, apiculate, reflexed, 7 to 7.5 mm wide; lamellae two, stout, parallel, conspicuously pubescent with white glandular hairs, ending abruptly with the lateral lobes, but continued to the middle lobe as raised lines. Column about 12 mm long. Anther broadly triangular-ovoid. Pollinia obliquely ovoid, compressed.

LUZON, Benguet Subprovince, Baguio, Mrs. K. B. Day's gardens, *Bur. Sci. 85569 Eduardo Quisumbing,* October 20, 1931. Living plants originally collected by Mrs. K. B. Day in Baguio, Mountain Province.

The flowers are fragrant, the sepals and petals are white with a crimson central line which does not extend to their apices, the labellum is Bordeaux with oblique white and seafoam yellow lines on the lateral lobes and an amber yellow. The column is blackish red-purple; the anther sulphur yellow. Pedicellate ovary lumiere green.

Sikkim, Assam, and Perak (Waterloo) at altitudes from 800 to 1,200 meters.

From the three species of *Cymbidium* known to occur in the Philippines, *Cymbidium dayanum* is distinguished by its grass-like, tufted leaves and the color of the flowers.

Genus SARCOCHILUS R. Brown

SARCOCHILUS UNGUICULATUS Lindl. Plate 2, figs. 9 and 10; Plate 5, figs. 18 to 24; Plate 12, fig. 1.

Sarcochilus unguiculatus LINDL. in Bot. Reg. 26 (1840) Misc. p. 67, 32 (1846) sub. *t. 19;* Edit. in Allg. Berl. Gartenz. 14 (1846) 167; REICHB. F. in Walp. Ann. 6 (1863) 501, in Gard. Chron. II 15 (1881) 562; NAVES Novis. App. (1882) 238; ROLFE in Orch. Rev. 2 (1894) 231, 14 (1906) 273, *fig. 37;* RIDL. in Journ. Linn. Soc. 31 (1896) 298, Mat. Fl. Mal. Penin. 1 (1907) 175; AMES in Merr. in Journ. Roy. Asiat. Soc. Straits Branch, Special No. (1921) 196, in Merr. Enum. Philip. Fl. Pl. 1 (1925) 408.

Thrixspermum unguiculatum REICHB. F. Xen. Orch. 2 (1867) 122, in Flora 51 (1868) 53; WARNER and WILL. Orch. Alb. 6 (1887) *t. 266;* MIETHE, Orchis 6 (1912) 101, 102, *t. 24.*

Phalaenopsis Ruckeri HORT. ex Reichb. f. in Gard. Chron. New Ser. 15 (1881) 562, in textu.

Phalaenopsis Ruckeriana HORT. ex Warner and Will. Orch. Alb. 6 (1887) *t. 266,* in syn.

Sarcochilus aureus HOOK. F., Fl. Brit. Ind. 6 (1890) 35, in Ann. Roy. Bot. Gard. Calc. 5 (Cent. Ind. Orch.) (1895) 42, *t. 64.*

Thrixspermum aureum O. KTZE., Rev. Gen. Pl. 2 (1891) 682.

Sarcochilus unguiculatus Lindl. var. *aureus* RIDL., Mat. Fl. Mal. Penin. (1907) 175.

? *Phalaenopsis fugax* KRÄNZL. in Gard. Chron. III 14 (1893) 360; ROLFE in Orch. Rev. 13 (1905) 230.

Sarcochilus unguiculatus; racemo 3-4-floro, labelli unguiculati trilobi ungue convexo lineari lineâ mediâ exaratâ, laminâ cavâ, lobis lateralibus semi-ovatis obtusis intermedio supra trinervi subtus globoso apice papillaeformi.

A native of Manilla, where it was discovered by Mr. Cuming. The flowers are light straw-color, the side lobes of the labellum white streaked with crimson, and the middle lobe rounded, fleshy, and dotted with crimson. It is a rather pretty species, for which I am indebted to Mr. Bateman.

Plants erect in habit. Stems very short. Leaves disposed more or less horizontally, distichous, 7 to 8 mm distant, oblong or elliptic-oblong, rigid, firm, coriaceous, greenish, the lower surface purplish, 10.5 to 16 cm long, 4 to 5.5 cm wide, unequally bilobed at the apex. Scapes very short, issuing from the side of the stems among the lower leaves, purplish, 2- to 4-flowered, 1 to 5.5 cm long. Flowers very fragrant, 2.3 to 2.5 cm across. Pedicellate ovary about 1.5 cm long, primrose yellow. Lateral sepals oblong-elliptic, subacute, semioblique, slightly concave, 1.2 to 1.5 cm long, 4.5 to 5.5 mm wide, 5-nerved, colonial buff with a patch of eugenia red on the basal inner half and tipped with old rose. Dorsal sepal oblong-elliptic, subacute, cucullate, 1.2 to 1.5 cm long, 4.5 to 5.5 mm wide, 5-nerved, primrose yellow and tipped with pale rosolane purple. Petals narrowly oblong-elliptic, obtuse, 1.1 to 1.2 cm long, 4 to 4.5 mm wide, 3-nerved, primrose yellow lined in the middle with flesh pink. Labellum unguiculate, 3-lobed; claw convex, linear, median line smooth, eugenia red above, white below; lateral lobes semierect, oblong-ovate, rounded at the apex, about 4.5 mm long, 2 mm wide, naples yellow striped with eugenia red; middle lobe about 5 mm long, fleshy, white dotted with violet-purple, globose below, with a papilla above. Column cylindrical, about 4 mm long, marguerite yellow. Capsules oblong-cylindric, about 3 cm long, 1.2 cm in diameter, angled.

The original description of the species was based upon a specimen collected at Manila by Cuming, and according to Mr. Rolfe[3] the type plant flowered in the garden of Mr. Bateman in 1840. What is considered to be the same species was described as a *Phalaenopsis* (*P. fugax*), but the structure of the flower is far from being that of a *Phalaenopsis*.

LUZON, Manila, Mrs. Remedios C. Gonzales's gardens, *Bur. Sci. 85570 Eduardo Quisumbing,* July 11, 1932. Living specimens were said to have been collected in the mountains back of Antipolo, Rizal Province, Luzon.

This is the third time that *Sarcochilus unguiculatus* has come to the attention of the junior author during a period of four years, and while in the beginning he suspected that the species was separable from the true *S. pallidus* (Bl.) Reichb. f., additional data have convinced him of its distinctness. The flowers of *S. pallidus* last for a couple of hours only, opening early in the morning and generally wilting before noon, while records of the flowering of *S. unguiculatus* show that the flowers remain in good condition longer, opening the first day and wilting on the third day. It flowers from May to July.

Sarcochilus unguiculatus is distinct from *S. pallidus,* not only in the habit of the plant, but also in the following features. The leaves are disposed horizontally and are more rigid and tinged with purple on the lower surface. The racemes are decidedly shorter, the flowers are much smaller, the lateral lobes of the labellum are oblong-ovate while the papilla on the front of the middle lobe is not so abrupt or prominent.

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[3] Orch. Rev. 2 (1894) 231.

Genus PHALAENOPSIS Blume

PHALAENOPSIS EQUESTRIS (Schauer) Reichb. f. var. LEUCOTANTHE Reichb. f. Plate 2, figs. 7 and 8; Plate 11, fig. 2.

Phalaenopsis equestris (Schauer) Reichb. f. var. *leucotanthe* REICHB. F. in l'Orchidoph. 3 (1883) 490; AMES Orch. 2 (1908) 230, in Merr. Enum. Philip. Fl. Pl. 1 (1925) 414.

The original description reads as follows:

> Les pétales et les sépales sont blanc aussi pur que la neige. Le labelle également blanc ponte quelques taches citron sur les lobes lateroux.

Habit is similar to the species. Leaves oblong, elliptic-oblong or oblanceolate-oblong, 9 to 11 cm long, 4 to 5 cm wide, light green in color. Scape about 20 cm long, ascending, unbranched. Flowers about 1.4 cm across; pedicellate ovary about 2 cm long. Sepals oblong-lanceolate or ovate-lanceolate, obtuse, about 1.4 cm long, 6 to 7 mm wide, the lateral ones asymmetric. Petals elliptic, obtuse, about 12.5 mm long, 7 mm wide. Labellum 3-lobed; lateral lobes linear-spatulate, about 7 mm long, 2.5 mm wide, incurved; middle lobe ovate, acute, about 12 mm long, 7 mm wide. Column about 8 mm long.

LUZON, Manila, Mrs. Remedios C. Gonzales's gardens, *Bur. Sci. 85571 Eduardo Quisumbing*, October 30, 1931. The living plants were collected in the mountains of Rizal Province, near Antipolo.

Peduncles chrysolite green. Buds chartreuse yellow. Sepals and petals pure white or white with very faint line of pale rose-purple at the center. Column white at the base, apex pale rose-purple. Lateral lobes of the labellum white with the base suffused with amber yellow or citron, the apex sometimes slightly suffused with pale rose-purple; middle lobe white with honey yellow at the base or white tipped with pale rose-purple. Callus at base of middle lobe empire yellow and dotted with red.

The variety differs from the species in the color of the peduncles, floral buds, and flowers.

PHALAENOPSIS MICHOLITZII Rolfe. Plate 2, figs. 1 and 2; Plate 5, figs. 25 to 33; Plate 12, fig. 2.

Phalaenopsis Micholitzii ROLFE in Gard. Chron. III 8 (1890) 187, in Journ. des Orch. 1 (1890) 198, in Orch. Rev. 13 (1905) 229; AMES Orch. 5 (1915) 217, in Merr. Enum. Philip. Fl. Pl. 1 (1925) 415.

Since *Phalaenopsis Micholitzii* has never been adequately described, the following amplification is given.

Herba *P. Lueddemannianae* habitu. Caulis abbreviatus, paucifoliatus. Folia oblongo-oblanceolata, ad basim sensim angustata, carnosa. Scapi breves, simplices, pauciflori. Flores subflavidi et sine maculis. Sepala lateralia oblique ovata, acuta. Sepalum dorsale oblongo-ellipticum, obtusum. Petala ovato-elliptica, breviter unguiculata. Labellum trilobatum; lobi laterales erecti, subquadrato-oblongi, apice bidentato truncato; lobus intermedius rhombico-spathulatus, inferne unguiculatus, apice obtuse tridentatus; discus supra medium papillis capilliformibus numerosis ornatus. Columna flavida.

Habit similar to that of *P. Lueddemanniana* Reichb. f. Stem abbreviated. Leaves oblong-oblanceolate, 13 to 17.5 cm long, 5.5 to 7 cm wide, broadly obtuse at the apex, gradually tapering to the base, pale green, fleshy, thick, very slightly rigid, somewhat conspicuously nerved with yellowish nerves. Scapes simple, short, few-flowered, 3 to 6 cm long, appearing in the axils of the leaves or at the base of the stem near the roots; rachis very short. Flowers odorless, 6 to 6.5 cm across, yellowish, and absolutely without transverse bars on the sepals and petals, 1 or 2 opening at a time. Pedicellate ovary marguerite yellow, about 3.3 cm long, the ovary terete, not twisted. Lateral sepals obliquely ovate, acute, apiculate, 3.2 to 3.3 cm long, 1.6 to 1.7 cm wide, 9-nerved. Dorsal sepal oblong-elliptic, obtuse, 3.2 to 3.3 cm long, 1.5 to 1.6 cm wide, 9-nerved. Petals ovate-elliptic, obtuse, about 2.8 cm long, 1.7 cm wide, with shortly stalked base which is about 4 mm long, 7-nerved. Labellum fleshy, 3-lobed; lateral lobes erect, subquadrate-oblong, with a prominent fleshy callus above the middle, bidentate at the truncate apex, about 8 mm long, cadmium yellow; middle lobe rhombic-spatulate, about 1.9 cm long, narrowed below into a distinct claw about 7 mm long, obtusely tridentate at the apex when spread out, the irregular margins minutely crisped-undulate, marguerite yellow; disc (between the side lobes) with a ligulate sharply bidentate callus which extends (in the middle of the claw) into a median high keel dentate in front, and which is succeeded by an irregular longitudinal cluster of hairlike papillæ. Column about 1.2 cm long, marguerite yellow; anther white.

LUZON, Manila, Bureau of Science orchid house, *Bur. Sci. 85572 Eduardo Quisumbing,* February 3, 1932.

A living plant of this species was sent to the junior author by Mr. F. E. Shafer, an orchid enthusiast of Cebu, who purchased it from a peddler in Cebu. Its origin is unknown, but is doubtless Philippine. The plant presented to the junior author is still growing in the Bureau of Science orchid house, and has flowered twice already this year (February 3 and May 31, 1932), the flowers lasting about two weeks.

A species with the habit of *P. Lueddemanniana* Reichb. f., differing conspicuously in its yellowish flowers with absolutely no bars on the sepals and petals, and in the form of the middle lobe of the labellum.

Genus AËRIDES Loureiro

AËRIDES JARCKIANUM Schltr. Plate 3, figs. 1 and 2; Plate 6, figs. 1 to 8; Plate 13, fig. 1.

Aërides jarckianum SCHLTR. in Orchis 9 (1915) 53, *t. 5, figs. 15–21;* AMES in Merr. Enum. Philip. Fl. Pl. 1 (1925) 420; SUMMERHAYES in Bot. Mag. 155 (1932) *t. 9274.*

Aërides sp. SCHLTR. in Orchis 9 (1915) 29, in dos.

Aërides recurvipes J. J. SM. in Bull. Jard. Bot. Buitenz. III 8 (1926) 63.

The original description reads as follows:

Aërides Jarckianum Schltr. n. sp.

Planta epiphytica, habitu A. rubescenti (Rolfe) Schltr. similis cui affinis, c. 20 cm. alta; foliis loratis illis Rhynchostylidis retusa Bl. similibus, sed latioribus et minus carinatis; racemis leviter decurvis, dense multifloris, c. 25 cm. longis; cylindraceis; pedunculo c. 10 cm. longo; bracteis reflexis, ovatis subacutis, ovario multo brevioribus; floribus adscendentibus vel suberectis in racemo decurvo, glabris, roseis, illis A. rubescentis (Rolfe) Schltr. similibus, c. 1 cm. diametientibus; sepalo intermedio suborbiculari, apiculato, concavo, c. 5 mm. longo, lateralibus oblongis obtusis, c. 6 mm longis obliquis; petalis late et oblique ovalibus obtusis, sepalo intermedio paululo brevioribus; labello trilobo, c. 6 mm. longo, lobis lateralibus incurvis, oblique oblongis, obtusiusculis, intermedio antico incurvo, ligulato, apice obtuse tridentato, lateralibus plus duplo longiore calcare oblique conico, leviter arcuato-protuso, subacuto, c. 8 mm. longo, columna brevi generis, pede subduplo longiore incrassato, medio longitudinaliter foveolato, c. 3 mm. longo, ovario pedicellato subviscido, glabro, pedicello gracili incluso c. 1.7 cm. longo.

Stems curved or recurved, terete, 30 to 35 cm long. Leaves lorate, recurved, leathery, thinner than those of *Aërides quinquevulnerum* Lindl., 12 to 20 cm long, 2 to 3 cm wide, unequally bilobed at the apex, slightly carinate on the back. Racemes subpendulous, densely many-flowered, 10 to 15 cm long, with their peduncles 30 to 50 cm long; sheaths remote, tubular, ovate, obtuse, up to 13 mm long. Flowers odorless, 12 to 13 mm across, 18 to 19 mm long; bracts ovate, acute, reflexed, up to 6 mm long. Pedicellate ovary slender, 14 to 16 mm long. Lateral sepals convex, suborbicular, subtruncate or broadly rounded at the apex, about 7 mm long, 6 mm wide, 7-nerved. Dorsal sepal suborbicular-oblong, about 7 mm long, 4.5 to 5 mm wide, 7-nerved. Petals oblong-suborbicular or oval, rounded, about 6.5 mm long, 4 to 4.5 mm wide, 7-nerved. Labellum fleshy, trilobed; lateral lobes incurved and overlapping, joined to the middle lobe, falcate-oblong, obtuse or obliquely truncate, denticulate at the apex, about 3 mm long, 2 mm wide, the side margins entire; middle lobe lanceolate, strongly incurved at the tip, base covered by the infolded lateral lobes, narrowed to the obtuse, apiculate apex, 5.5 to 6 mm long, about 3 mm wide at the base, the margins entire. Spur conical, somewhat incurved, obtuse, 9 to 10 mm long. Column erect, very short, fleshy, stout, extended in a long slightly convex foot, about 8 mm long including the foot which has two thickened ridges on each side. Anther broadly triangular, beaked.

LUZON, Manila, Bureau of Science orchid house, *Bur. Sci. 80815, 80836 Eduardo Quisumbing,* October, 1930.

Living plants were collected in the mountains of Rizal Province, by Novaliches orchid collectors, at medium altitudes.

Pedicellate ovary cameo pink to almost white; sepals and petals white dotted with light mallow pink; middle lobe of the labellum phlox purple to magenta; lateral lobes of the labellum phlox pink spotted with magenta; the spur magenta. Flowering season from December to February.

A species often mistaken locally for *Anota violacea* (Lindl.) Schltr. However, the two species are conspicuously differentiated by the floral parts. It differs from *Aërides quinquevulnerum* Lindl. in being a more slender plant, in the size and color of the flowers, and in the structure of the floral parts particularly the labellum. The species is allied to *Aërides Leeanum* Reichb. f., differing in the shape and details of the labellum.

AËRIDES JARCKIANUM Schltr. var. **SMITHII** var. nov. Plate 3, figs. 3 and 4; Plate 6, figs. 9 to 16; Plate 13, fig. 2.

A typo foliis latioribus sepalis lateralibus saepissimi truncatis et floribus paulo majoribus intensius coloratis differt.

Plant more robust than the species. Leaves 13 to 19 cm long, 3.5 to 4 cm wide, about 2 mm thick, more distichous, broader and more rigid than in the species. Racemes 11 to 19 cm long, with the peduncles 26 to 62 cm long. Flowers more intensely colored than in the species, flower parts not so spreading as in the species, about 10 mm across, 20 to 21 mm long. Pedicellate ovary mallow purple, 20 to 22 mm long. Lateral sepals bent forward, with the anterior margin slightly involute, subquadrate, truncate, about 7.5 mm long, 6.5 mm wide, 7-nerved.

Dorsal sepal strongly cucullate, subquadrate-oval, rounded, about 7 mm long, 6 mm wide, 7-nerved. Petals suborbicular, rounded, about 6 mm long, 5.5 mm wide, 5-nerved. Labellum 3-lobed; lateral lobes not overlapping completely as in the species but overlapping only by the anterior margins, broadly falcate-oblong, truncate, denticulate at the apex, about 7.5 mm long, 3.5 mm wide; middle lobe oblong, broadly obtuse at the apex, the very tip slightly incurved, about 7.5 mm long, 3.75 mm wide. Spur as in the species, about 11 mm long. Column stout, fleshy, about 8.5 mm long including the foot.

LUZON, Manila, Mrs. Remedios C. Gonzales's gardens, *Bur. Sci. 80816 Eduardo Quisumbing,* October 6, 1930.

The living plants were collected originally in the same locality as the species. Basal half of the lateral sepals light mallow pink, upper half magenta; spur, dorsal sepal, and petals magenta. Labellum magenta except the apical four-fifths of the lateral lobes which is cameo pink. Column white; anther naphthalene yellow.

The variety is chiefly distinguished from the species by its more robust stems, more distichous, thicker wider leaves, more intensely colored and larger flowers and truncate lateral sepals.

This interesting variety is dedicated to Dr. J. J. Smith, an indefatigable student of Indo-Malaysian orchids, particularly those of Sumatra and Java, who has helped us to identify the species. The determination was accidental while Doctor Smith was studying the true status of the so-called *Anota violacea* from the Philippines.

AËRIDES QUINQUEVULNERUM Lindl. var. ALBUM Williams. Plate 2, figs. 3 and 4; Plate 6, figs. 17 to 25; Plate 14, fig. 1.

Aërides quinquevulnerum Lindl. var. *album* WILLIAMS in Orch. Grow. Man. ed. 2 (1862) 41.

Aërides quinquevulnerum Lindl. var. *Farmeri* WILLIAMS apud Stein Orchideenb. (1892) 63; WILLIAMS, Orch. Grower's Man. ed. 7 (1894) 90; AMES Orch. 2 (1908) 253, in Merr. Enum. Philip. Fl. Pl. 1 (1925) 422.

Aërides Farmeri BOXALL ex Naves Novis. App. (1882) 239, nomen.

Aërides album SANDER apud Stein Orchideenb. (1892) 63, in syn.

"A white variety of the preceding, (*A. quinquevulnerum*), producing long spikes of white flowers; grows like *quinquevulnerum,* and blooms about the same time." Ex Orch. Grower's Man. ed. 2 (1862) 41.

In habit similar to the species. Roots fleshy, greatly elongated, 5 to 9 mm in diameter. Stems unbranched, terete, 15 to 30 cm long, 1.2 to 1.3 cm in diameter. Leaves more distichous than in the species, carinate, coriaceous, 18 to 30 cm long, 3 to 4 cm wide. Racemes axillary, drooping, many-flowered, 20 to 30 cm long. Flowers very fragrant, pure white, fleshy and waxy, about 20 mm across. Pedicellate ovary 13 to 15 mm long. Sepals and petals spreading. Lateral sepals suborbicular-ovate, rounded at the apex, 10 to 11 mm long, 7 to 8 mm wide 7-nerved. Dorsal sepal suborbicular-oval, broadly obtuse, 7.5 to 9 mm long, about 7 mm wide, 5-nerved. Petals suborbicular-obovate, minutely acute at the rounded apex, 8.5 to 9.5 mm long, 5.5 to 6.5 mm wide, 5-nerved. Labellum 3-lobed; lateral lobes erect, oblong-semiorbicular, oblique, about 7 mm long, 6 mm wide; middle lobe concealed by the lateral lobes, lanceolate, incurved, about 8 mm long. Column short, stout, erect, with the foot 8 to 10 mm long. Anther ovoid; pollinia subglobose.

LUZON, Manila, Mrs. Remedios C. Gonzales's gardens, *Bur. Sci. 85573 Eduardo Quisumbing,* October 26, 1932.

The plants were originally collected by Mr. Aleko Lilius at an altitude of 100 to 130 meters in the hills of Calayan Island, Babuyan group, north of Luzon.

This variety differs from the species in its white flowers, more compact racemes, and more distichous leaves. This extremely rare orchid is remarkable for the elegance of its spikes of pure white, very fragrant flowers, which lasted for over a month. Since its appearance at Mr. W. F. G. Farmer's[4] place in Nonsuch Park, Cheam, England, in 1862, this is the first time it has been shown in Manila, and apparently the second in the world.

Genus LUISIA Gaudichaud

LUISIA CORDATILABIA sp. nov. Plate 3, figs. 9 and 10; Plate 6, figs. 26 to 33; Plate 14, fig. 2.

Herba epiphytica. Caules adscendentes, simplices (ver rarissime ramosi), 30 ad 80 cm alti, 5 ad 6 mm in crassitudine. Folia teretia, 9 ad 13.5 cm longa, 4 ad 5 mm in crassitudine, basi ad vaginas rigidas articulata. Inflorescentiae oppositifoliae; pedunculus circiter 2 cm longus; rhachis crassa; bracteae rigidae, cucullatae, usque ad 4 mm longae. Flores carnosi, rigidi, 1.8 ad 2 cm lati, bracteis triangularibus, acutis, persistentibus subtenti; pedicellus cum ovario 12 ad 13 mm longus. Sepala lateralia valde navicularia, carinata, oblique lanceolata vel ovato-lanceolata, acuta vel subacuta, circiter 11 mm longa, 5 mm lata, 3-nervia. Sepalum dorsale lanceolato-oblongum, obtusum vel subacutum cum apice cucullato, 10 ad 11 mm longum, 4.5 ad 5 mm latum, 3-nervium. Petala elliptico-lanceolata, obtusa, valde obliqua, carnosa, sepalis majora, 12 ad 13 mm longa, circiter 6 mm lata, 5-nervia. Labellum incrassatum, trilobatum, 10.5 ad 11 mm longum; lobi laterales erecti, subquadrati, truncati, circiter 3 mm longi, 2 mm alti; lobus medius perlate cordatus, obtusus, 7 ad 7.5 mm longus, 9 ad 10 mm latus. Columna crassa, circiter 5 mm longa. Anthera subquadrata, complanata. Pollinia 2, subglobosa, circiter 1.5 mm longa.

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[4] Williams, Orchid Grower's Manual ed. 7 (1894) 90.

An epiphytic herb. Stems ascending, simple (only one case of branching was noted), 30 to 80 cm high, 5 to 6 mm in diameter. Leaves dark green, fleshy, terete, slightly tapered to the apex, 9 to 13.5 cm long, 4 to 5 mm in diameter, articulated to rigid sheaths, internodes 2 to 3 cm long. Inflorescences situated opposite the leaves, stout; peduncles up to 2 cm long; bracts rigid, cucullate, triangular, up to 4 mm long, acute at the apex. Flowers fleshy, odorless, rigid, 1.8 to 2 cm across; floral bracts brownish, acute, persistent; pedicellate ovary 12 to 13 mm long, twisted at the base. Lateral sepals strongly navicular, carinate, membranaceous, obliquely lanceolate or ovate-lanceolate, acute or subacute, about 11 mm long, 5 mm wide, 3-nerved. Dorsal sepal lanceolate-oblong, membranaceous, slightly concave, obtuse or subacute with a strongly cucullate apex, 10 to 11 mm long, 4.5 to 5 mm wide, 3-nerved. Petals elliptic-lanceolate, obtuse, fleshy at the apex, 12 to 13 mm long, about 6 mm wide, 5-nerved, spreading. Labellum 3-lobed, thickened, the middle lobe much so, 10.5 to 11 mm long; lateral lobes erect, subquadrate, truncate, about 3 mm long, 2 mm high; middle lobe very broadly cordate, obtuse, 7 to 7.5 mm long, 9 to 10 mm wide, with vertical ridges on the upper surface, the very tip recurved. Column stout, about 5 mm long. Anther subquadrate, flattened. Pollinia 2, subglobose, about 1.5 mm long.

LUZON, Benguet Subprovince, Baguio, Mansion House gardens, *Bur. Sci. 82227 Eduardo Quisumbing,* May 6, 1931.

The plants were first found in the orchid gardens of the Governor General's Palace in Baguio. The origin of these plants is not definitely known, but they were doubtless collected by the Igorots from the hills close to Baguio.

Pedicel sea-foam yellow; ovary Kildare green, dorsal sepal and petals deep sea-foam green dotted with pale rose-purple; lateral sepals deep sea-foam green at the base, the rest vinaceous-cinnamon; anther cap ivory yellow; column pale grass green lined and dotted at the base with dahlia purple; labellum dull dark purple.

This is an ally of *Luisia teretifolia* Gaudich. from which it is distinguished by the size of the flowers, by the relatively broad petal, and by the unbranched habit of the stems.

Genus VANDA Jones

VANDA LAMELLATA Lindl. var. REMEDIOSAE var. nov. Plate 1, figs. 9 and 10; Plate 7, figs. 1 to 9; Plate 15, figs. 1 and 2.

Planta erecta; folia quam in specie breviora, minus curvata, 13 ad 16 cm longa.

Stems erect, slender, terete, about 75 cm long, 1.2 cm in diameter. Leaves relatively short, ligulate-lorate, channeled, slightly curved, 13 to 16 cm long, 2.5 to 3.2 cm wide when expanded, the apex unequal, acute. Racemes longer than the leaves, erect, bearing from 19 to 23 flowers, 33 to 37 cm long including the peduncles. Flowers fragrant, intermediate in size between those of *V. lamellata* Lindl. and *V. lamellata* var. *boxallii* Reichb. f., 3.7 to 4 cm across. Pedicellate ovary 4 to 4.3 cm long. Lateral sepals ovate-spatulate, obtuse, subfalcate, 1.7 to 1.9 cm long, 1 to 1.2 cm wide. Dorsal sepal elliptic-oblanceolate, minutely acute at the rounded apex, 2 to 2.2 cm long, 7 to 8 mm wide. Petals elliptic-oblanceolate, acute, 1.9 to 2.1 cm long, 6.5 to 7 mm wide. Spur narrowly conical, obtuse, somewhat flattened, 5 to 6 mm long. Labellum 3-lobed, 1.1 to 1.2 cm long; lateral lobes asymmetrically ovate, broadly rounded, erect, about 4 mm long; middle lobe pandurate-subquadrate, retuse, constricted in the middle of each side, 9 to 10 mm long, 6 to 7 mm wide at the widest portion near the base, traversed longitudinally by two prominent keels, which are broadest in the middle. Column 5 to 6 mm long. Pollinia subglobose.

LUZON, Manila, Mrs. Remedios C. Gonzales's gardens, *Bur. Sci. 85575 Eduardo Quisumbing,* May 23, 1932.

The plants were originally collected from Jolo, Mindanao, with no definite locality. Since its arrival in Manila the plant has flowered three times (May 23, 1932, November 8, 1932, and January 20, 1933). The flowers remain fresh for about a month. Pedicellate ovary whitish. Dorsal sepal and petals white, their bases lined with ferrugineus; lateral sepals marguerite yellow, the inner half citron green and lined longitudinally with buff-citrine; lateral lobes of the labellum white; middle lobe of the labellum pale rosolane purple marked at the base with six vinaceous-rufous lines, the two outer ones forking at the base. Column white.

This variety differs from the typical forms of *Vanda lamellata* in its erect stems, short and but slightly curved leaves. The flowers are larger than in usual forms of the species, and the color of the flower is distinct especially the middle lobe of the labellum.

This variety is dedicated to Mrs. Remedios C. Gonzales to whom the junior author owes great favors for her kindness in putting at his disposal for study her large collections of orchids and for her great interest in Philippine orchids.

VANDA MERRILLII Ames and Quisumbing var. IMMACULATA var. nov. Plate 2, figs. 5 and 6.

Haec varietas floribus omnino luteis haud striatis neque maculatis a *Vanda Merrillii* differt.

In habit and flower parts similar to the species. The flowers are slightly larger; the sepals, petals, and middle lobe of the labellum primuline yellow, with pinard yellow in the center. The lateral lobes of the labellum, column, and pedicellate ovary are white.

LUZON, Manila, Mrs. Remedios C. Gonzales's gardens, *Bur. Sci. 85574 Eduardo Quisumbing*, November 8, 1932.

The plant was originally collected by orchid peddlers from the mountains near Atimonan, Tayabas Province, Luzon. Since its arrival in Manila the plant had flowered twice (May 23 and November 8, 1932).

The variety is characterized by the complete absence of bars or maculations on the sepals and petals.

Genus STAUROPSIS Reichenbach f.

This genus was proposed in 1860 (Hamb. Gartenz. 16: 117) and briefly characterized as follows: "Gynostemium apus. Sepala a labello libera." As exemplifying these characters, *Trichoglottis philippinensis* Lindl. was referred here.

Later the genus *Stauropsis* was amplified by Bentham [in Bentham & Hook. f. Gen. Pl. 3 (1883) 572], where the distinction from the allied genera still rested on the footless column, while the lip was described as ecalcarate.

The type description of the allied genus *Trichoglottis* Bl. [Bijdr. (1825) 359] showed the base of the sepals adnate to a distinct column foot and the lip conspicuously spurred.

While several species subsequently referred to *Trichoglottis* appear to have a footless column and spurless lip, the vast majority of *Trichoglottis,* including all the Philippine orchids which logically belong to that genus, have prominent spurs. It appears to us, therefore, that the genus *Stauropsis* should be retained for the Philippine orchids of this alliance, which are distinguished by an ecalcarate lip and footless column. Accordingly, the following transfers are made and a key to the Philippine members of the genus *Stauropsis* appended.

Key to the Philippine species of Stauropsis.

1. Flowers in racemes; peduncles elongate, about 7 cm long; labellum cruciform, with prominent keel .... *S. fasciata.*
1. Flowers solitary, opposite the axils of the leaves; peduncles very short or none.
    2. Labellum 5-lobed, cruciform, with prominent elongate keel; middle lobe of labellum elongate, linear.
        3. Lateral lobes of labellum (not the erect basal lobes) narrowly triangular to obliquely quadrate-oblong. *S. philippinensis.*
        3. Lateral lobes of labellum acinaciform-linear; sepals and petals within victoria lake. *S. philippinensis* var. *brachiata.*
    2. Labellum 3-lobed, not cruciform (with short basal lobes only), provided with a distinct rounded callus; middle lobe ovate-lanceolate with a caudate apex.. *S. Wenzelii.*

STAUROPSIS FASCIATA Benth.

Stauropsis fasciata BENTH. apud Jackson in Ind. Kew. (1885) 892; AMES and QUISUMBING in Philip. Journ. Sci. 47 (1932) 214, *pls. 2, 12, 28, and 29.*

LUZON, Manila, Bureau of Science orchid house, *Bur. Sci. 80831 Eduardo Quisumbing,* May 26, 1930.

The living plants were collected from Atimonan, Tayabas Province, Luzon. They occur also in eastern tropical Asia; namely, Siam, Lankawi, etc.

Stauropsis fasciata Benth. differs from all other Philippine species in its elongate racemes and in the color and form of its flowers.

STAUROPSIS PHILIPPINENSIS (Lindl.) Reichb. f. Plate 2, figs. 11 to 13; Plate 7, figs. 19 to 27; Plate 16, fig. 1.

Stauropsis philippinensis (Lindl.) REICHB. F. in Hamb. Gartenz. 16 (1860) 117, Xen. Orch. 2 (1862) 8, in Walp. Ann. 6 (1864) 882; VIDAL Rev. Pl. Vasc. Filip. (1886) 270; AMES Orch. 2 (1908) 223, 5 (1915) 224, in Merr. Enum. Philip. Fl. Pl. 1 (1925) 440.

Trichoglottis philippinensis LINDL. in Ann. & Mag. Nat. Hist. 15 (1845) 386; NAVES Novis. App. (1882) 243; VIDAL Phan. Cuming. Philip. (1885) 150; USTERI Beitr. Ken. Philip. Veg. (1905) 128; AMES Orch. 7 (1922) 137, in Merr. Enum. Philip. Fl. Pl. 1 (1925) 440.

The original description reads as follows:

> "* * * foliis subrotundo-ovatis emarginatis mucrone interjecto, sepalis oblongo-lanceolatis patulis, petalis reflexis linearibus brevioribus, labello esaccato pubescente secus axin villoso oblongo convexo apice hastato-trilobo dentibus baseos brevibus rotundatis. Philippines. Cuming." Lindley, loc. cit.

Tall, branched epiphyte (the herbarium specimens often simple). Roots greatly elongate, simple or branched, whitish. Stems erect (often tending to twist) up to 130 cm high, 5 to 10 mm in diameter, somewhat flattened; internodes up to 2.5 cm long. Leaves light green, oblong, oblong-ovate, or ovate-elliptic, distichous, retuse, mucronate, carinate, 2 to 9 cm long, 1.4 to 3.5 cm wide, thick, rigid. Flowers solitary, opposite the axils of the leaves, odorless or fragrant, lasting for several weeks on the stems without drying, 3 to 3.5 cm across, fleshy. Peduncles very short or none. Bracts imbricate at the base, minute, membranaceous. Lateral sepals ovate to lanceolate, acute, 1.5 to 1.9 cm long, 8 to 10 mm wide, apex abruptly recurved. Dorsal sepal lanceolate-elliptic, acute to subacute, 1.5 to 1.8 cm long, 3.5 to 8 mm wide. Petals narrower than the sepals, linear-oblanceolate or narrowly elliptic-lanceolate, subacute or obtuse, 1.5 to 1.7 cm long, 4 to 4.5 mm wide. Labellum 5-lobed, cruciform, acute, 14 to 19 mm long; two basal lobes erect, triangular, short, subacute or obtuse, 1.75 to 2 mm long, firmly united with the column at the base; lateral lobes near the middle triangular to subquadrate-oblong, acute to obliquely truncate, white, 1.5 to 7.5 mm long. Entire disc laterally flattened and fleshy, 3 to 7 mm thick, strongly angled below near the apex, white, upper surface villose with white hairs; beneath the hairs mallow pink. Between the basal lobes within the shallow sac there is a quadrate yellow hairy appendage. Column fleshy, stout, about 6 mm long.

Cuming 2140 (Philippines), without definite locality (type of *Trichoglottis philippinensis* Lindl. in Herb. Brit. Mus.).

LUZON, Bulacan Province, Angat, *Bur. Sci. 21680 Ramos,* September 23, 1913: Cavite Province, Maragondong, *Merrill 4188,* July 30, 1930: Rizal Province, Mt. Alban, *Loher 6023,* July 9, 1905. NEGROS, Hermosa, *For. Bur. 17460 Curran,* September 29, 1909. CEBU, Algot, *Lange 18630,* November, 1928. PALAWAN, without definite locality, *Watling 17574,* May, 1927. MINDANAO, Surigao Province, Surigao, *Bur. Sci. 34542 Ramos and Pascasio,* April 9, 1919: Misamis Province, without definite locality, *For. Bur. 19519 W. Klemme,* January, 1911: Davao Province, Astorga, *Copeland, s. n.* April 29, 104; *Mati, Bur. Sci. 49026 Ramos and Edaño,* June 28, 1929. TAWI-TAWI, Sulu Province, *Bur. Sci. 44245 Ramos and Edaño,* July 19, 1924.

A common endemic species in the Philippines, up to 300 meters altitude. The typical form is colored thus: Sepals and petals are margined with primrose yellow, at the center deep colonial buff or honey yellow to orange-cinnamon with the base Etruscan red. Labellum white with mallow pink on both sides of the central ridge; appendage in the sac between the basal lobes yellow. Column white with a liseran purple line around it.

A species characterized by its cruciform 5-lobed labellum and its solitary flowers opposite the axils of the leaves.

In the herbarium of the Bureau of Science are two plants with different colored flowers. These plants must be referred to this species. The data are: (*a*) *Bur. Sci. 85576 Eduardo Quisumbing,* May 20, 1929. Living plant originally was collected by the late Mr. Maximo Ramos from Catanduanes. Sepals and petals white to marguerite yellow, splashed or barred with dragon's blood red or jasper red (Plate 2, fig. 12). (*b*) *Bur. Sci. 85557 Eduardo Quisumbing,* August 8, 1931. Living plant was originally collected in Davao Province, without definite locality. Sepals and petals are madder brown and margined by reed yellow (Plate 2, fig. 13).

STAUROPSIS PHILIPPINENSIS (Lindl.) Reichb. f. var. **BRACHIATA** (Ames) comb. nov. Plate 3, figs. 11 and 12; Plate 7, figs. 10 to 18; Plate 16, fig. 2.

Trichoglottis brachiata AMES Orch. 7 (1922) 136, in Merr. Enum. Philip. Fl. Pl. 1 (1925) 440.

The original description reads as follows:

"Aff. *T. philippinensis* Lindl. Caules plus minusve 30 cm alti, rigidi, usque ad apicem foliati, vaginis foliorum obtecti, usque ad 8 mm. in crassitudine, internodiis 1.4 cm. longis. Folia plus minusve 4.5 cm. longa, 2.9 cm. lata, oblongo-elliptica, disticha, retusa, apiculata, apiculo rigido, acuto. Flores laterales, e nodis orientes, singuli. Pedicellus cum ovario usque ad 3.5 cm. longus. Sepala lateralia patentia, 21 mm. longa, 11 mm. lata, ovato-lanceolata, acuta, coriacea. Sepalum dorsale simile. Petala 2 cm. longa, 6 mm. lata, anguste lanceolata, utrinque attenuata, subacuta, valde coriacea, patentia. Labellum 19 mm. longum, quinquelobatum, usque ad medium columnae affixum, ecalcaratum, basi saccatum vel valde concavum; lobi basilares erecti, trianguli, carnosi, circa 3 mm. alti, intus minute pubescentes; lobi laterales 8 mm. longi, usque ad 1.5 mm. lati, acinaciformes, apice inaequaliter dentati, utrinque minute pubescentes; lobus terminalis a latere complanatus, 9 mm. longus, 5 mm. altus, carnosus, cuneato-quadratus, angulo superiore valde elongato, utrinque pubescens, supra pilosus; discus carina valde carnosa ornatus, prope basim appendicula quadrata, truncata, carnosa instructus. Colmuna brevis, 7 mm. longa, minute pubescens." Ames, loc. cit.

Stems erect, rigid, up to 56 cm high, 5 to 8 mm in diameter; internodes 1 to 1.5 cm long. Leaves ovate-oblong or broadly oblong-elliptic, 3 to 8 cm long, 2.5 to 4 cm wide, distichous, thickly coriaceous, rigid, retuse, apiculate; the apicule rigid, acute. Flowers lateral, appearing singly at the nodes opposite the leaves, 3 to 4.5 cm across. Pedicellate ovary twisted, 3 or more cm long. Sepals and petals spreading and star-shaped. Lateral sepals thickly coriaceous, ovate or ovate-lanceolate, acute, 2 to 2.5 cm long, 1 to 1.5 cm wide. Dorsal sepal similar in form and texture, 1.7 to 1.9 cm long, 1 to 1.4 cm wide. Petals thickly coriaceous, lanceolate or oblong-elliptic, narrowed at both ends, subacute or obtuse at the apex, 1.9 to 2 cm long, 6 to 7 mm wide. Labellum 19 to 25 mm long, 5-lobed, adnate to the lower half of the column, ecalcarate, the base saccate or strongly concave; basal lobes erect, triangular, fleshy, 2.5 to 4 mm high, glabrous without and minutely pubescent within; lateral lobes 6 to 8 mm long, up to 4 mm wide, acinaciform, unequally dentate at the apex, minutely pubescent on both surfaces; middle lobe laterally flattened, about 14 to 18 mm long from the base of the basal lobes, 2.5 to 5 mm high, fleshy, elongate-cuneate, disc with a prominent fleshy keel which is pilose above. Between the basal lobes there is a quadrate, truncate callus which is minutely pubescent. Column stout, 7 to 8 mm long, minutely pubescent.

LUZON, Manila, Bureau of Science orchid house, *Bur. Sci. 85613 Eduardo Quisumbing,* August 14, 1930. Living plants were collected by orchid peddlers from Tayabas Province. Other collections in the herbarium of the Bureau of Science, Manila, are as follows: BILIRAN, *Bur. Sci. 18931 McGregor* (type), June 23, 1914. PALAWAN, near the shores between Cataban and Pancol, *Ermitaño 17577,* May, 1927. MINDANAO, Agusan Province, Cabadbaran, *Weber 134* (this number shows transition to *S. philippinensis*) : Davao Province, Todaya, Mount Apo, *Elmer 12021.*

An endemic variety usually found on tree trunks at low altitudes. Sepals and petals light cadmium on the outer surface, victoria lake inside, except the margins, tips, and a central line, which are light cadmium. Labellum rhodamine purple, except the white pilose hairs above the ridge and the center of the lateral lobes of the labellum ivory yellow. Blooms in Manila gardens usually around August. The plants thrive on adobe stone walls and in wooden baskets.

This variety differs from the species in its Victoria lake color of the inside of the flowers, and its elongate, linear, curved lateral lobes of the labellum, which arise near the middle of the central lobe.

STAUROPSIS WENZELII (Ames) comb. nov. Plate 3, figs. 14 and 15; Plate 7, figs. 28 to 35; Plate 17.

Trichoglottis Wenzelii AMES in Philip. Journ. Sci. 8 (1913) Bot. 440, Orch. 5 (1915) 257, in Merr. Enum. Philip. Fl. Pl. 1 (1925) 440.
Trichoglottis retusa AMES in Philip. Journ. Sci. 4 (1909) Bot. 676, non Blume, in Merr. Enum. Philip. Fl. Pl. 1 (1925) 440.

The original description reads as follows:

> "Herba epiphytica circiter 30 cm alta, rigida. Caules foliosi, internodiis 1.5–2 cm longis. Foliorum vaginae cylindraceae, supra paulo dilatatae, internodiis aequilongae, laminae valde coriaceae, in sicco rugosae, oblongae, 4.5–6 cm longae, circiter 1.5 cm latae, distichae, ad apicem subaequaliter rotundato-bilobae vel retusae. Inflorescentiae oppositifoliae, foliis breviores. Bracteae rigidae, 2 mm longae. Flores inter maximos generis, purpureo-maculati, circiter 2 cm in diametro. Sepala lateralia oblonga, subacuta ad basim late cuneata, carnosa, 1 cm longa, 6 mm lata. Sepalum dorsale simile. Petala spathulata, 9–10 mm longa, prope apicem 3 mm lata. Labellum breve saccatum, 3-lobatum, lobis lateralibus brevibus obtusis, utrinque pubescentibus, lobo medio elongato, attenuato, sagittato-lanceolato, apice attenuato, acuto, usque ad 13 mm longo, pubescenti. Callus in disco, pubescens. Ligula ante foveam pubescens 4 mm longa. Gynostemium pubescens auriculis elongatis, pilosis, 4 mm longis." Ames, Philip. Journ. Sci. 8 (1913) Bot. 440.

Epiphyte; the roots greatly elongate. Stems rigid, foliose, erect, or more or less arcuate, 25 to 75 cm high, 4 to 7 mm in diameter; internodes 1.5 to 4 cm long. Leaf sheaths cylindric, dilated at the apex, and as long as the internodes. Leaves oblong to ligulate, leathery, rugose when dry, 4 to 12 cm long, 1.1 to 2.5 cm wide, distichous, unequally bilobed or retuse at the apex with rounded lobules. Inflorescences opposite the leaves and much shorter than the leaves. Bracts rigid, tubular, about 2 mm long. Flowers fragrant, in life 1.6 to 1.7 cm across, 2 to 2.5 cm across when fully expanded. Pedicellate ovary somewhat twisted, about 1.3 cm long. Lateral sepals fleshy, ovate to oblong, subacute, 8 to 13 mm long, 5 to 7 mm wide, 6- to 7-nerved. Dorsal sepal oblong-obovate, acute to subacute, apiculate, 7.1 to 11 mm long, 4.2 to 6.25 mm wide, 5- to 6-nerved. Petals spatulate or oblong-spatulate, 7 to 10 mm long, 2 to 3 mm wide at the widest portion, 3-nerved. Labellum 3-lobed, shallowly saccate at the base, fleshy, 12.8 to 17 mm long when expanded; basal lobes short, triangular, obtuse, 1.5 to 2.5 mm long, free portion about 1.6 mm, pubescent; middle lobe ovate to ovate-lanceolate, about 13 mm long, attenuate or caudate at the apex (with tail 5.5 to 7 mm long), glabrous below and pubescent above. Between the basal lobes there is a ligulate, pubescent appendage which is 2.8 to 3 mm long. Keel beneath the middle lobe narrow and thin. Gynostemium pubescent, the auricles elongate, pilose, 2.5 to 2.9 mm long.

LUZON, Tayabas Province, Pitogo, *For. Bur. 9653 Curran,* March 23, 1908: Camarines Sur Province, Mount Bagacay, *Bur. Sci. 33850 Ramos and Edaño,* December 17, 1918. NEGROS, Occidental Negros Province, along Gimogaa River, *For. Bur. 5553 H. D. Everett,* October 26, 1906. LEYTE, Dagami, *Wenzel 15* (Type of *Trichoglottis Wenzelii* Ames), December 8, 1912, *Wenzel 176.* MINDANAO, Surigao Province, Surigao, *F. H. Bolster 225,* January 17, 1906; *W. S. Lyon 127:* Davao Province, Davao, *Rev. R. F. Black, s. n.* 1909: Zamboanga Province, Malasugat, *Merrill 8206,* November–December, 1911. TAWITAWI, Sulu Province, *Bur. Sci. 44262 Ramos and Edaño,* August 22, 1924. BASILAN, *For. Bur. 6103 Hutchinson,* August, 1906. A species growing at lower altitudes. Endemic.

Sepals and petals chalcedony yellow or light green-yellow, striped with amaranth purple. Labellum cream-colored, barred with amaranth purple with the white pilose hairs on the upper surface of the middle lobe.

The species is characterized by having a trilobed labellum, of which the middle lobe is ovate to ovate-lanceolate, attenuate or caudate at the apex.

ILLUSTRATIONS

PLATE 1

FIG. 1. *Dendrobium Aliciae* sp. nov., front view of flower, × 1.
2. *Dendrobium Aliciae* sp. nov., side view of flower, × 1.
3. *Bulbophyllum surigaense* sp. nov., side view of flower, × 1.5.
4. *Bulbophyllum surigaense* sp. nov., front view of flower, × 1.5.
5. *Dendrobium plicatile* Lindl. var. *Convocarii* var. nov., front view of flower, × 1.
6. *Dendrobium plicatile* Lindl. var. *Convocarii* var. nov., side view of flower, × 1.
7. *Cymbidium dayanum* Reichb. f., front view of flower, × 1.
8. *Cymbidium dayanum* Reichb. f., side view of flower, × 1.
9. *Vanda lamellata* Lindl. var. *Remediosae* var. nov., front view of flower, × 1.
10. *Vanda lamellata* Lindl. var. *Remediosae* var. nov., side view of flower, × 1.

PLATE 2

FIG. 1. *Phalaenopsis Micholitzii* Rolfe, front view of flower, × 1 (circa).
2. *Phalaenopsis Micholitzii* Rolfe, side view of flower, × 1 (circa).
3. *Aërides quinquevulnerum* Lindl. var. *album* Williams, side view of flower, × 1.
4. *Aërides quinquevulnerum* Lindl. var. *album* Williams, front view of flower, × 1.
5. *Vanda Merrillii* Ames and Quisumbing var. *immaculata* var. nov., front view of flower, × 1.
6. *Vanda Merrillii* Ames and Quisumbing var. *immaculata* var. nov., side view of flower, × 1.
7. *Phalaenopsis equestris* (Schauer) Reichb. f. var. *leucotanthe* Reichb. f., front view of flower, × 1.
8. *Phalaenopsis equestris* (Schauer) Reichb. f. var. *leucotanthe* Reichb. f., side of view of flower, × 1.
9. *Sarcochilus unguiculatus* Lindl., front view of flower, × 1.
10. *Sarcochilus unguiculatus* Lindl., side view of flower, × 1.
11. *Stauropsis philippinensis* (Lindl.) Reichb. f., (typical form), front view of flower, × 1.
12. *Stauropsis philippinensis* (Lindl.) Reichb. f., front view of flower, × 1.
13. *Stauropsis philippinensis* (Lindl.) Reichb. f., front view of flower, × 1.
14. *Stauropsis Wenzelii* (Ames) comb. nov., front view of flower, × 1.
15. *Stauropsis Wenzelii* (Ames) comb. nov., side view of flower, × 1.

PLATE 3

FIG. 1. *Aërides Jarckianum* Schltr., front view of flower, × 2.
2. *Aërides Jarckianum* Schltr., side view of flower, × 2.
3. *Aërides Jarckianum* Schltr. var. *Smithii* var. nov., front view of flower, × 2.
4. *Aërides Jarckianum* Schltr. var. *Smithii* var. nov., side view of flower, × 2.
5. *Dendrobium irayense* sp. nov., front view of flower, × 2.
6. *Dendrobium irayense* sp. nov., side view of flower, × 2.
7. *Dendrobium Yeageri* sp. nov., front view of flower, × 1 (circa).
8. *Dendrobium Yeageri* sp. nov., side view of flower, × 1 (circa).
9. *Luisia cordatilabia* sp. nov., front view of flower, × 2.
10. *Luisia cordatilabia* sp. nov., side view of flower, × 2.
11. *Stauropsis philippinensis* (Lindl.) Reichb. f. var. *brachiata* (Ames) comb. nov., front view of flower, × 1.
12. *Stauropsis philippinensis* (Lindl.) Reichb. f. var. *brachiata* (Ames) comb. nov., side view of flower, × 1.

PLATE 4

Dendrobium Aliciae sp. nov.: *1*, dorsal sepal, × 1.5; *2*, lateral sepal, × 1.5; *3*, petal, × 1.5; *4*, front view of column and labellum (natural position), × 2.5 (circa); *5*, labellum from above, stretched out, × 3; *6*, side view of ovary, column, and labellum (natural position), × 3; *7*, anther from above, (enlarged); *8*, anther from below, (enlarged); *9*, pollinia, (enlarged).

Dendrobium plicatile Lindl. var. *Convocarii* var. nov.: *10*, dorsal sepal, × 1 (circa); *11*, lateral sepal, × 1 (circa); *12*, petal, × 1 (circa); *13*, front view of column, and labellum (natural position), × 1.5 (circa); *14*, labellum from above, stretched out, × 1.5 (circa); *15*, side view of column, ovary, and labellum (natural position), × 1.5 (circa); *16*, anther from below, × 6; *17*, anther from above, × 6; *18*, group of pollinia, × 6.5; *19*, a pollinium, × 6.5.

Dendrobium irayense sp. nov.: *20*, dorsal sepal, × 2 (circa); *21*, lateral sepal, × 2 (circa); *22*, petal, × 2 (circa); *23*, side view of pedicellate ovary, column, and labellum (natural position), × 2.4 (circa); *24*, labellum from above (flattened), × 2.4 (circa); *25*, front view of column, × 1.5 (circa); *26*, anther from above, × 10 circa); *27*, anther from below, × 10 (circa); *28*, pollinia, × 8 (circa).

Dendrobium Yeageri sp. nov.: *29*, dorsal sepal, × 1.5 (circa); *30*, petal, × 1.5 (circa); *31*, lateral sepal, × 1.5 (circa); *32*, labellum from above (stretched out), × 1.5 (circa); *33*, side view of labellum, column, and pedicellate ovary (natural position), × 1.5 (circa); *34*, anther from above, × 7; *35*, anther from below, × 7; *36*, front view of column, × 1.5 (circa); *37*, pollinia, × 7.

PLATE 5

Bulbophyllum surigaense sp. nov.: *1*, a bract, × 3 (circa); *2*, dorsal sepal, × 3 (circa); *3*, lateral sepal, × 3 (circa); *4*, petal, × 3 (circa); *5*, front view of column, and labellum (natural position), × 6 (circa); *6*, side view of ovary, column, and labellum (natural position), × 6 (circa); *7*, anther from above, × 14; *8*, anther from below, × 14; *9*, pollinia, × 14.

Cymbidium dayanum Reichb. f.: *10*, dorsal sepal, × 1 (circa); *11*, lateral sepal, × 1 (circa); *12*, petal, × 1 (circa); *13*, side view of column, and labellum (natural position), × 1.5 (circa); *14*, front view of column, and labellum from above (stretched out), × 1.5 (circa); *15*, anther from above, × 8 (circa); *16*, anther from below, × 8 (circa); *17*, pollinia, × 8 (circa).

Sarcochilus unguiculatus Lindl.: *18*, dorsal sepal, × 2; *19*, petal, × 2; *20*, lateral sepal, × 2; *21*, side view of column, and labellum (natural position), × 2; *22*, column and labellum from above, with the lateral lobes of the labellum stretched out, × 2; *23*, front view of column without anther, × 8; *24*, fruit, × 1 (circa).

Phalaenopsis Micholitzii Rolfe: *25*, dorsal sepal, × 0.75; *26*, petal × 0.75; *27*, lateral sepal, × 0.75; *28*, side view of column, and labellum (natural position), × 1.5; *29*, front view of column, and labellum (natural position), × 1.5; *30*, labellum from above (stretched out) 1.5; *31*, anther from above, × 4.5; *32*, anther from below, × 4.5; *33*, pollinia, × 7.5.

PLATE 6

Aërides Jarckianum Schltr.: *1*, dorsal sepal, × 3; *2*, lateral sepal, × 3; *3*, petal, × 3; *4*, side view of pedicellate ovary, column, and labellum (natural position), × 2 (circa); *5*, front view of column, and labellum (natural position), × 2 (circa); *6*, anther from above, × 6 (circa); *7*, anther from below, × 6 (circa); *8*, pollinia, × 9 (circa).

Aërides Jarckianum Schltr. var. *Smithii* var. nov.: *9*, dorsal sepal, × 3 (circa); *10*, lateral sepal, × 3 (circa); *11*, petal, × 3 (circa); *12*, side view of pedicellate ovary, column, and labellum (natural position), × 2 (circa); *13*, front view of column, and labellum (natural position), × 2 (circa); *14*, anther from above, × 6 (circa); *15*, anther from below, × 6 (circa); *16*, pollinia, × 9 (circa).

Aërides quinquevulnerum Lindl. var. *album* Williams: *17*, dorsal sepal, × 3 (circa); *18*, lateral sepal, × *3* (circa); *19*, petal, × 3 (circa); *20*, front view of labellum (natural position), × 4; *21*, side view of labellum, and portion of column (natural position), × 2 (circa); *22*, front view of column, × 2 (circa); *23*, anther from above, × 5 (circa); *24,* anther from below, × 5 (circa); *25,* pollinia, × 10 (circa).

Luisia cordatilabia sp. nov.: *26,* dorsal sepal, × 2 (circa); *27,* petal, × 2 (circa); *28,* lateral sepal, × 2 (circa); *29,* front view of column, and labellum (natural position), × 2 (circa); *30,* side of pedicellate ovary, column, and labellum (natural position), × 2 (circa); *31,* anther from above, × 4 (circa); *32,* anther from below, × 4 (circa); *33,* pollinia in two views, × 4 (circa).

PLATE 7

Vanda lamellata Lindl. var. *Remediosae* var. nov.: *1,* dorsal sepal, × 1.5 (circa); *2,* lateral sepal, × 1.5 (circa); *3,* petal, × 1.5 (circa); *4,* side view of ovary, column, and labellum (natural position), × 2 (circa); *5,* labellum from above (natural position), × 2 (circa); *6,* labellum from above (stretched out), × 2 (circa); *7,* anther from above, × 8 (circa); *8,* anther from below, × 8 (circa); *9,* pollinium, × 8 (circa).

Stauropsis philippinensis Lindl. var. *brachiata* (Ames) comb. nov.: *10,* dorsal sepal, × 2; *11,* petal, × 2; *12,* lateral sepal, × 2; *13,* side view of ovary, column, and labellum (natural position), × 2; *14,* column and labellum from above (natural position), × 2; *15,* labellum from above (stretched out), × 2; *16,* anther from above, × 5.5 (circa); *17,* anther from below, × 5.5 (circa); *18,* pollinia, × 5.5 (circa).

Stauropsis philippinensis (Lindl.) Reichb. f.: *19,* dorsal sepal, × 1.5 (circa); *20,* lateral sepal, × 1.5 (circa); *21,* petal, × 1.5 (circa); *22,* labellum from above with lateral lobes stretched out, × 1.5 (circa); *23,* side view of ovary, column, and labellum, (natural position), × 1.5 (circa); *24,* front view of column, and labellum (natural position), × 1.5 (circa); *25,* anther from above, × 8 (circa); *26,* anther from below, × 8 (circa); *27,* pollinia, × 8 (circa).

Stauropsis Wenzelii (Ames) comb. nov.: *28,* dorsal sepal, × 2 (circa); *29,* lateral sepal, × 2 (circa); *30,* petal, × 2 (circa); *31,* side view of ovary, column, and labellum (natural position), × 2 (circa); *32,* labellum from above, stretched out, × 2 (circa); *33,* front view of column, and labellum, × 2 (circa); *34,* views of anthers from above and from below, × 8 (circa); *35,* pollinia, × 8 (circa).

PLATE 8

FIG. 1. *Dendrobium Aliciae* sp. nov., habit, very much reduced.
2. *Dendrobium plicatile* Lindl. var. *Convocarii* var. nov., habit, very much reduced.

PLATE 9

FIG. 1. *Dendrobium irayense* sp. nov., habit, very much reduced.
2. *Dendrobium Yeageri* sp. nov., habit very much reduced.

PLATE 10

FIG. 1. *Bulbophyllum surigaense* sp. nov. habit, very much reduced.
2. *Bulbophyllum surigaense* sp. nov., flowers, almost natural size.

PLATE 11

FIG. 1. *Cymbidium dayanum* Reichb. f., habit, very much reduced.
2. *Phalaenopsis equestris* (Schauer) Reichb. f. var. *leucotanthe* Reichb. f., habit, reduced.

PLATE 12

FIG. 1. *Sarcochilus unguiculatus* Lindl., habit, and fruits, much reduced.
2. *Phalaenopsis Micholitzii* Rolfe, habit, much reduced.

PLATE 13

FIG. 1. *Aërides Jarckianum* Schltr., habit, very much reduced.
2. *Aërides Jarckianum* Schltr. var. *Smithii* var. nov., habit, very much reduced.

PLATE 14

FIG. 1. *Aërides quinquevulnerum* Lindl. var. *album* Williams, habit, very much reduced.
2. *Luisia cordatilabia* sp. nov., habit, very much reduced.

PLATE 15

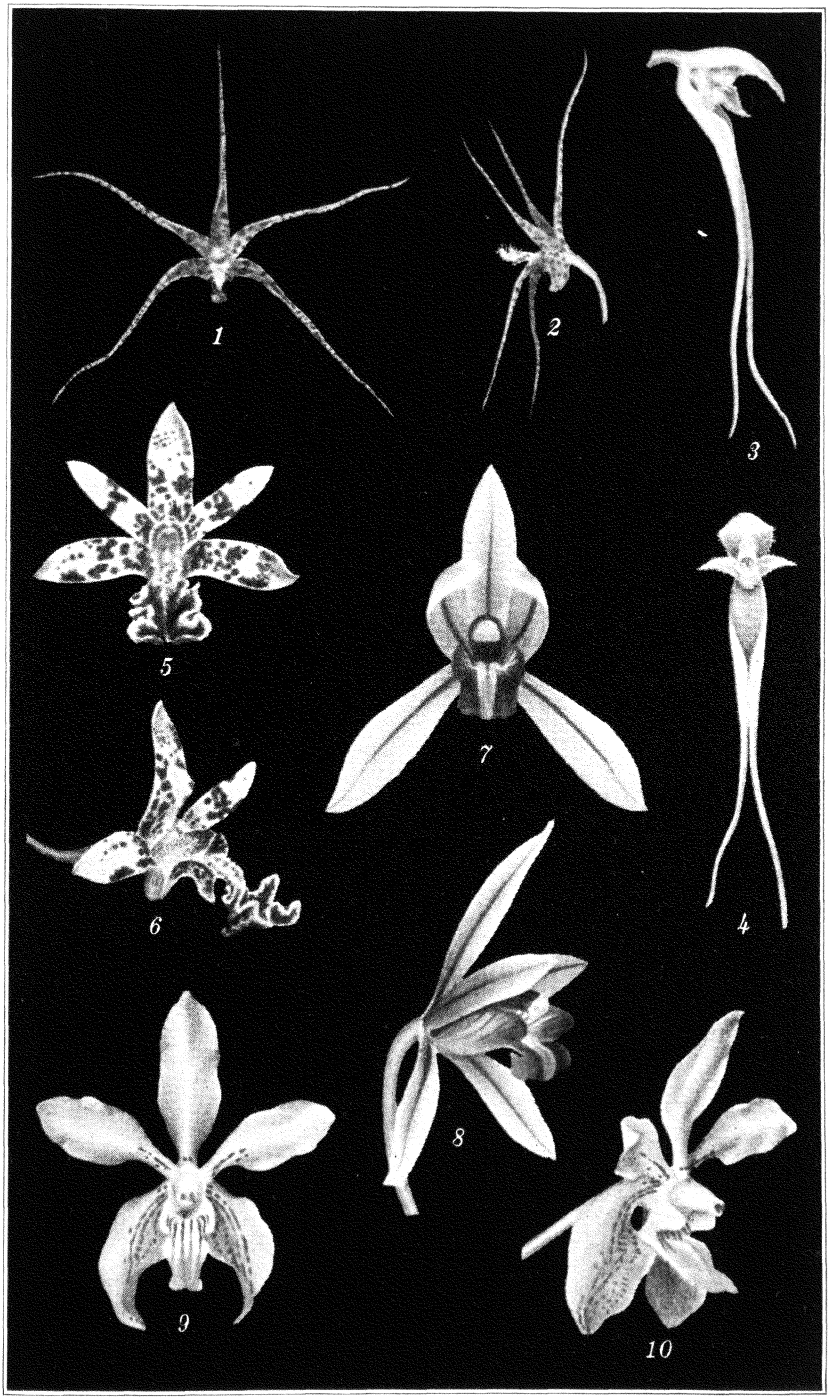
FIG. 1. *Vanda lamellata* Lindl. var. *Remediosae* var. nov., habit, very much reduced.
2. *Vanda lamellata* Lindl. var. *Remediosae* var. nov., flowers, slightly enlarged.

PLATE 16

FIG. 1. *Stauropsis philippinensis* (Lindl.) Reichb. f., habit, very much reduced.
2. *Stauropsis philippinensis* (Lindl.) Reichb. f. var. *brachiata* (Ames) comb. nov., habit, very much reduced.

PLATE 17

Stauropsis Wenzelii (Ames) comb. nov., habit, very much reduced.



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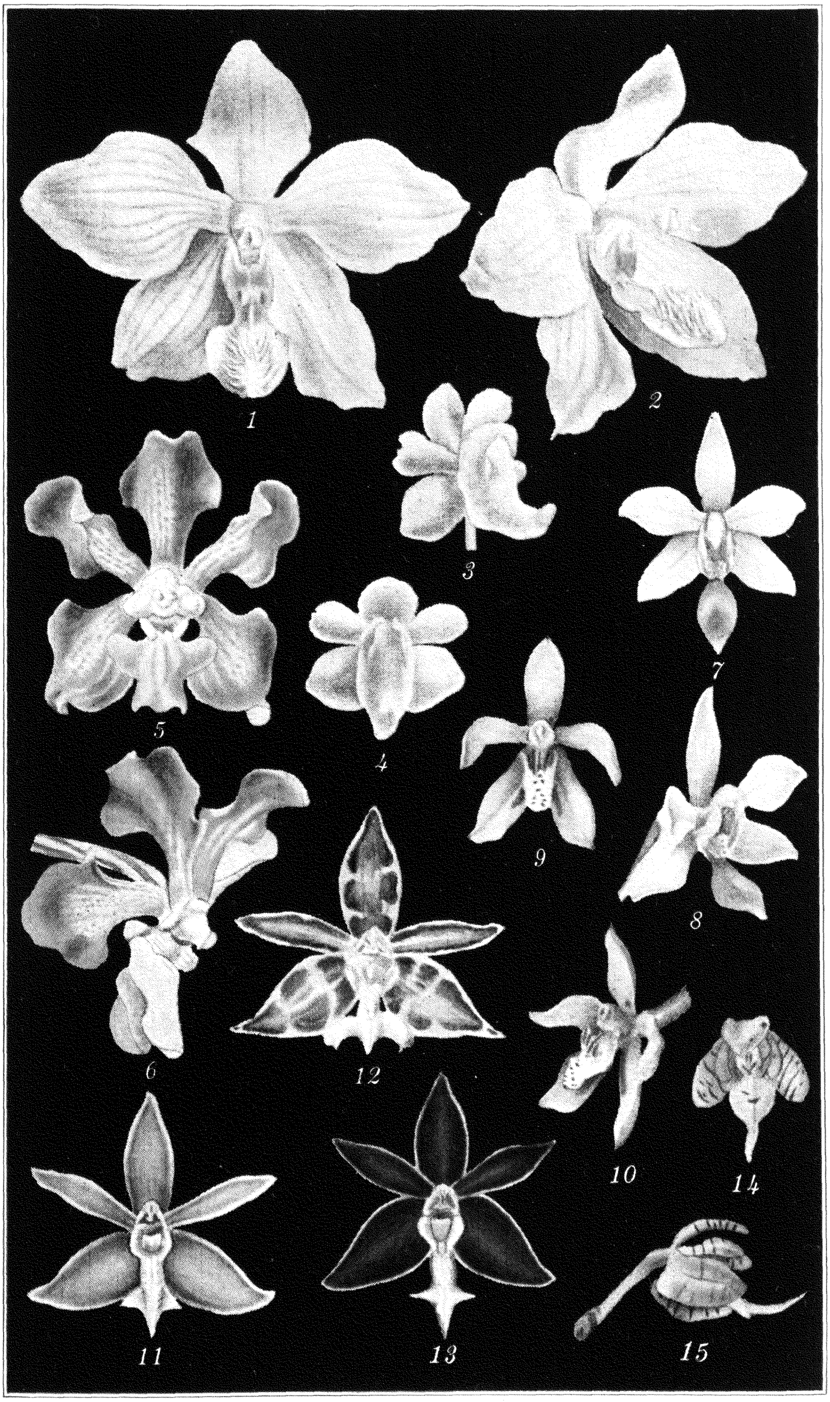

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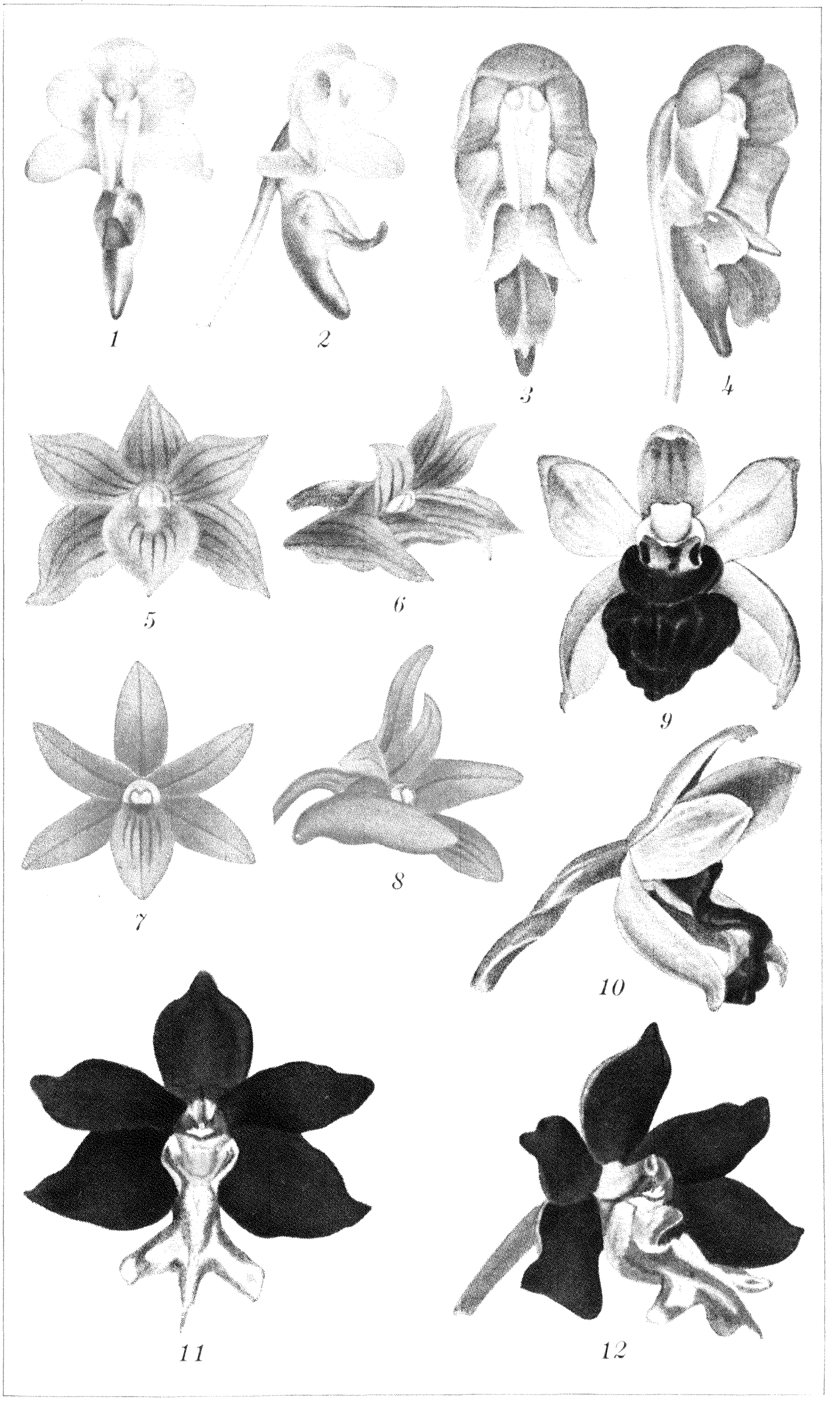

PLATE 3.

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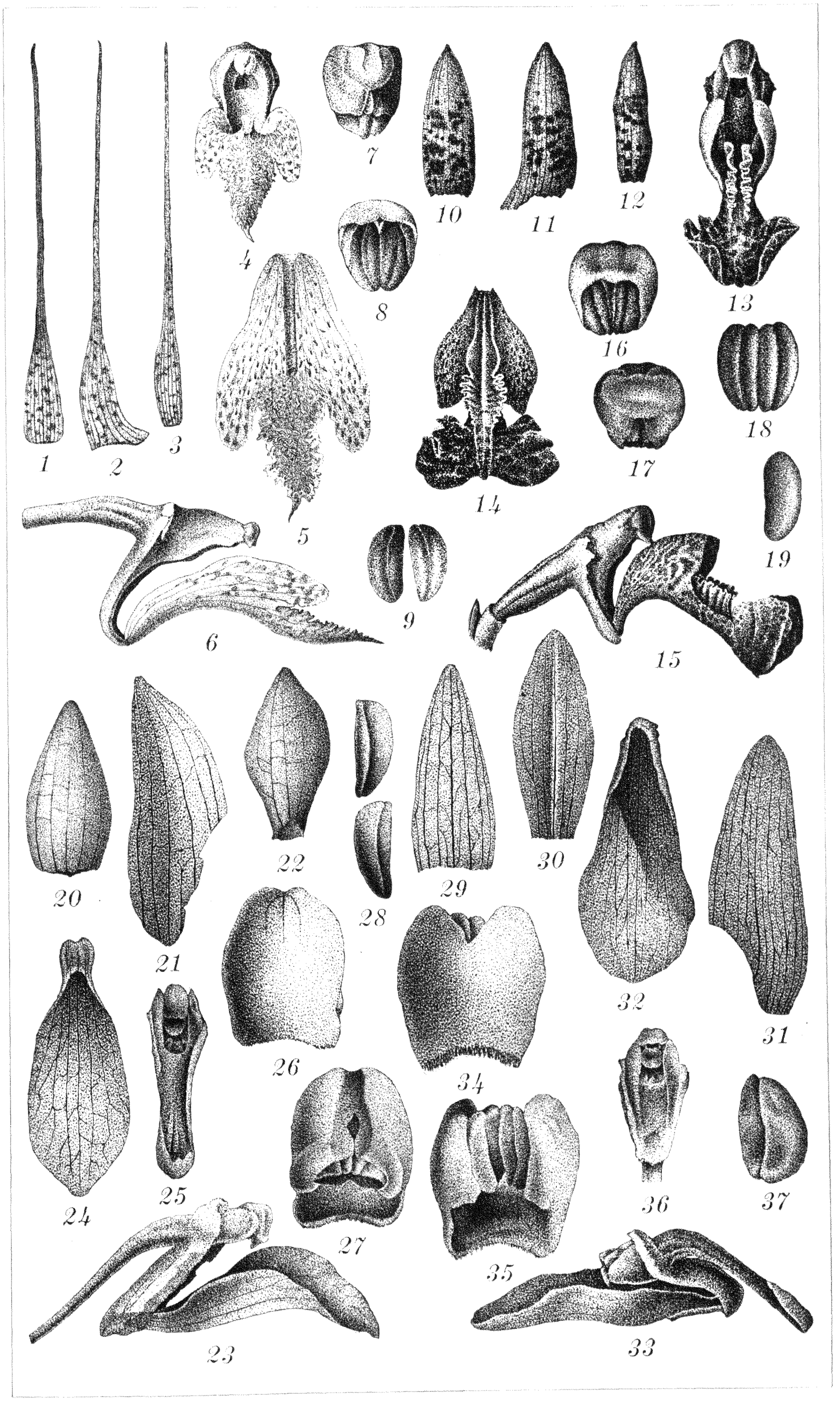

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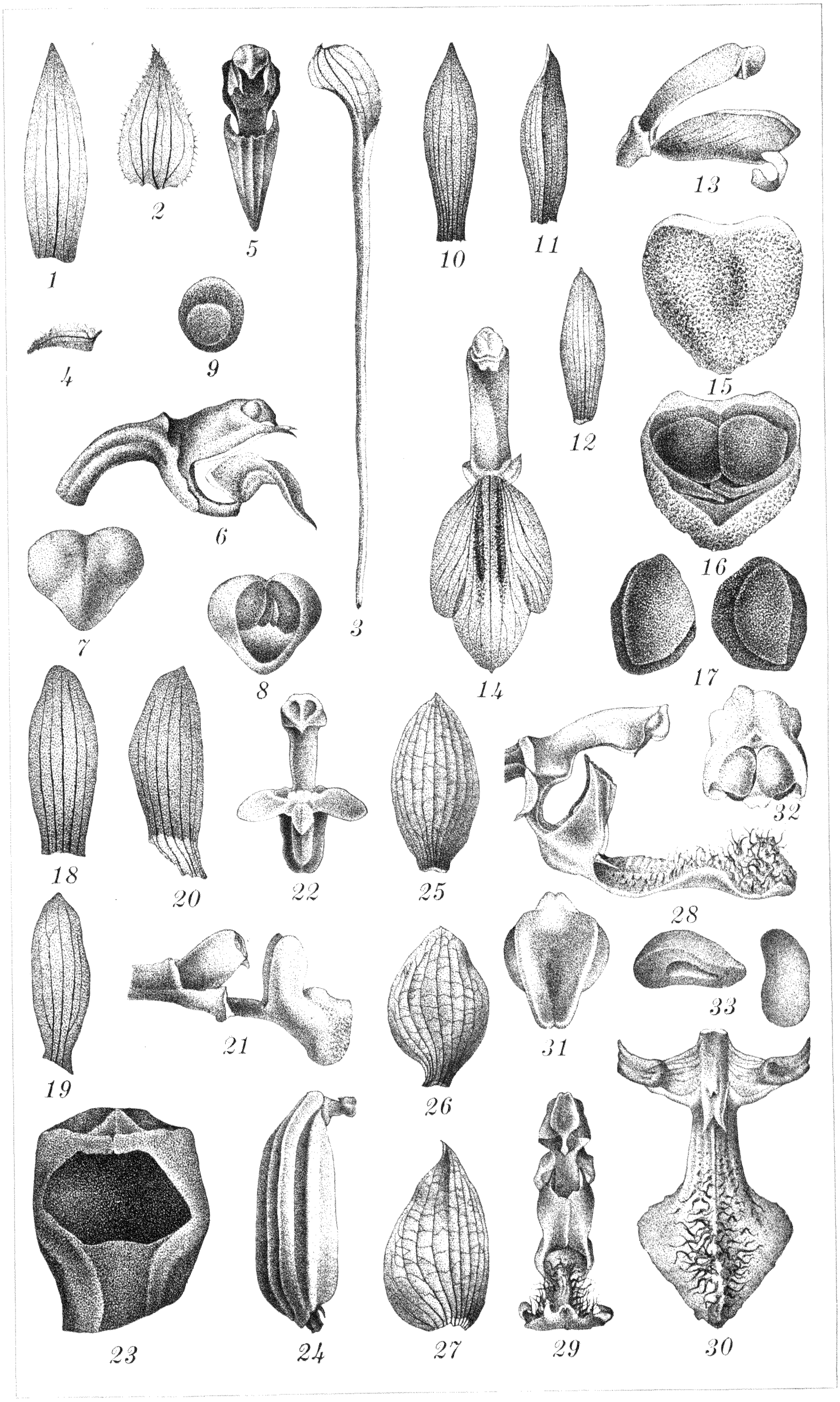
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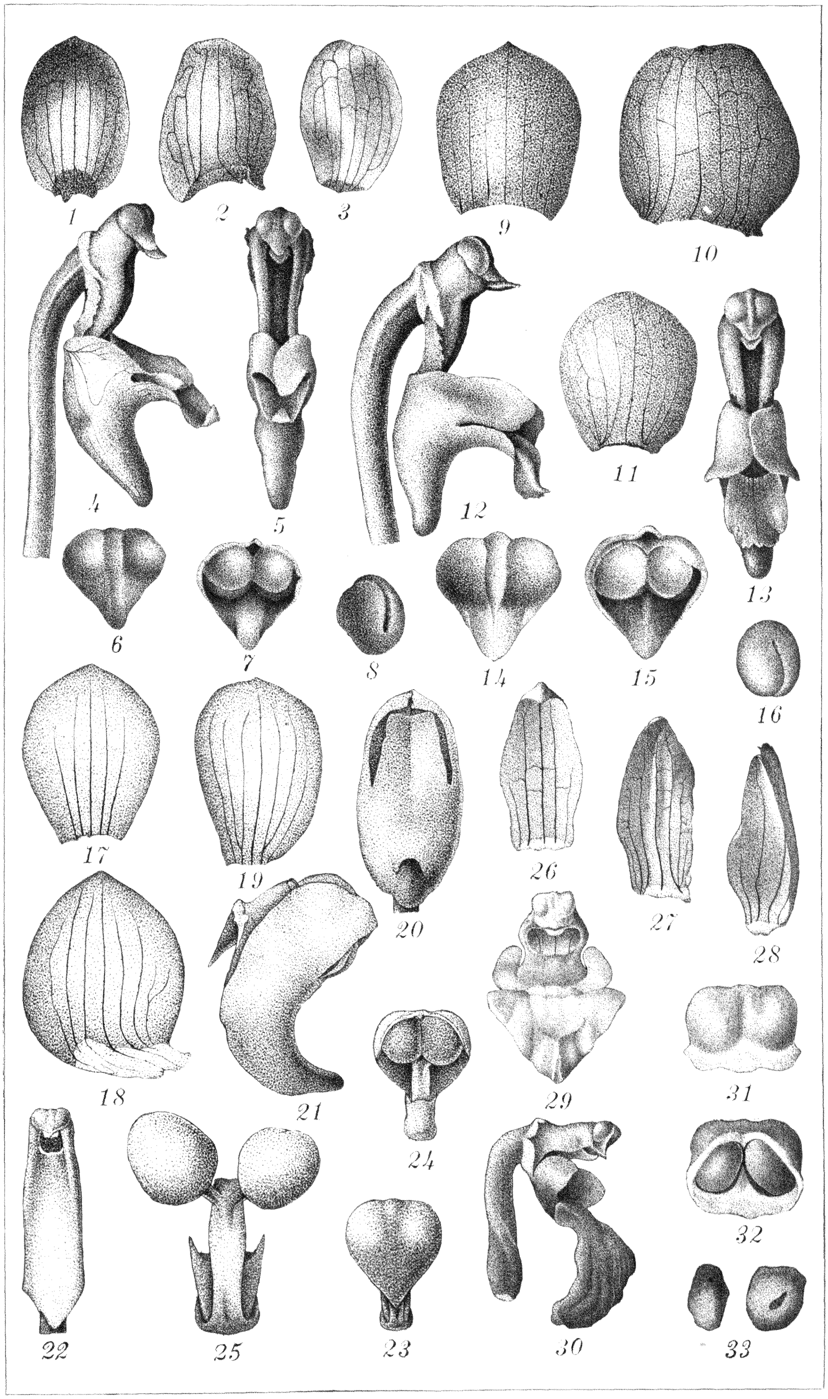
PLATE 5.



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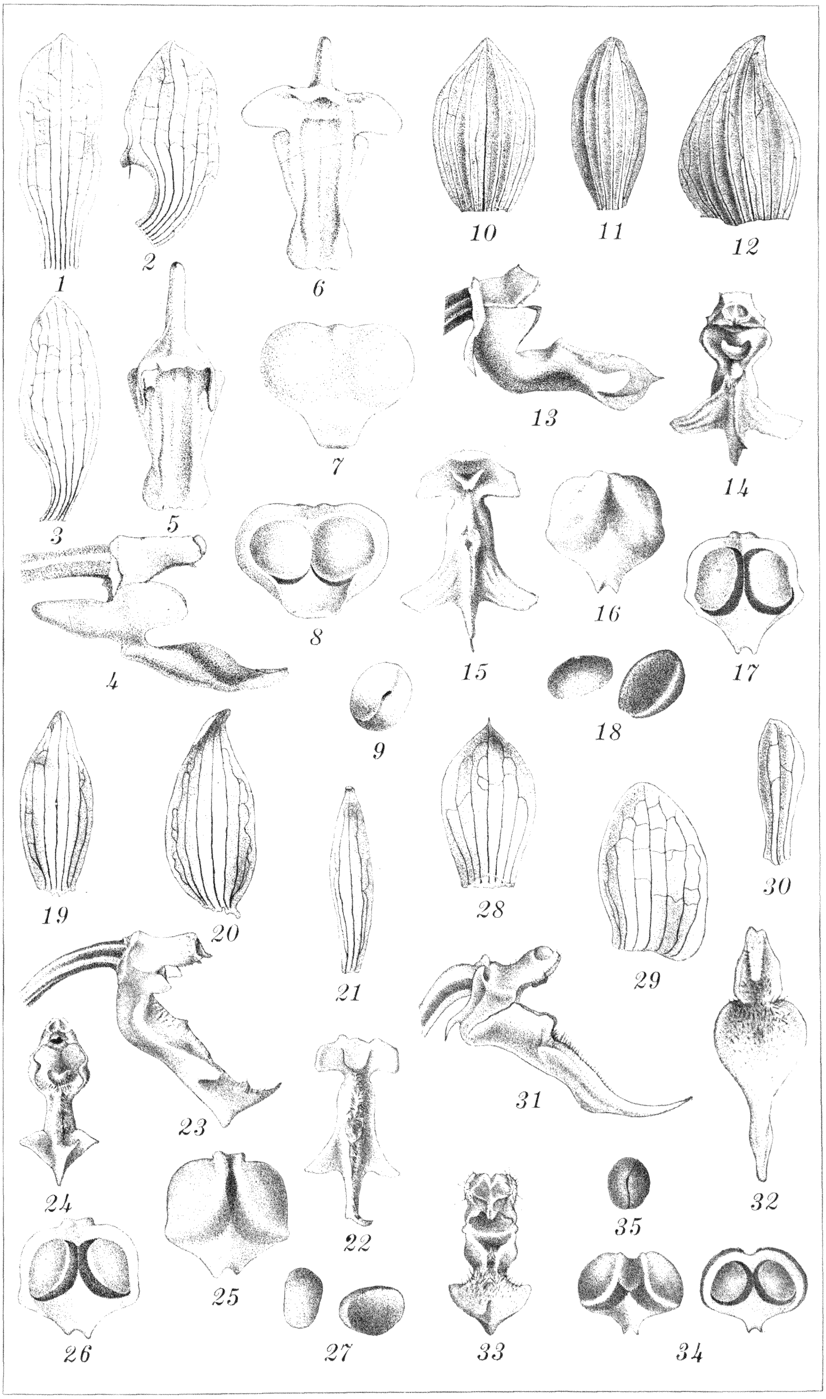

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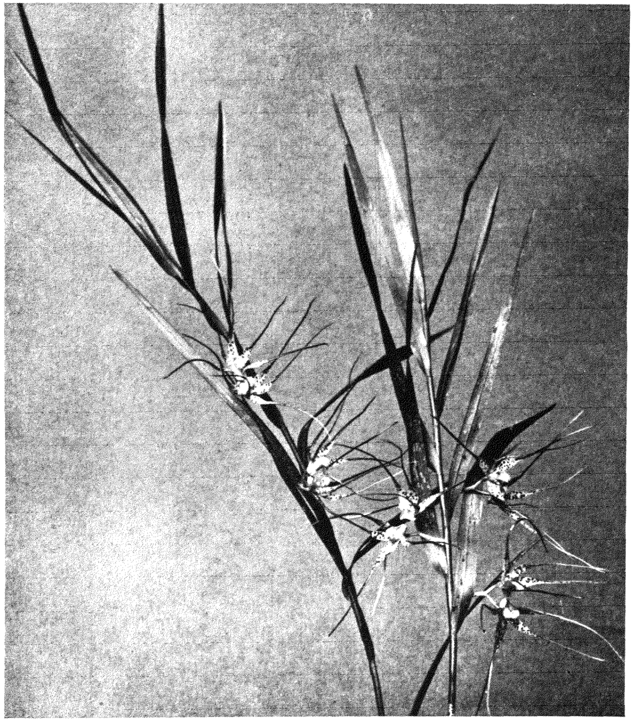

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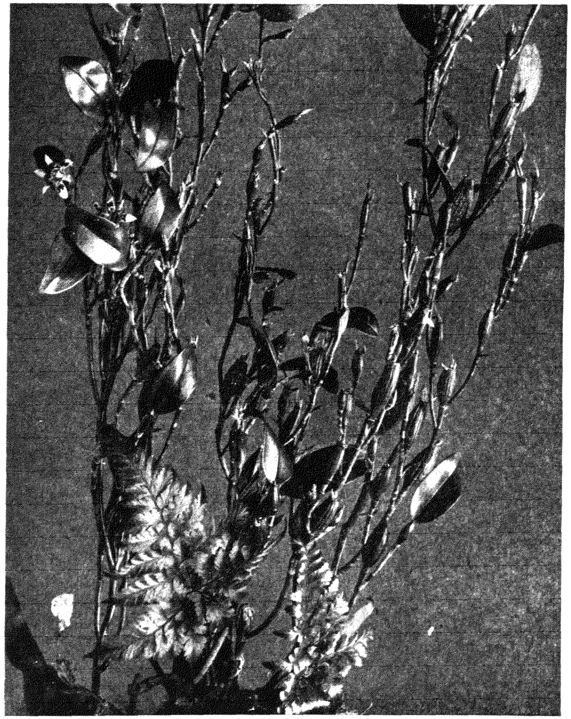

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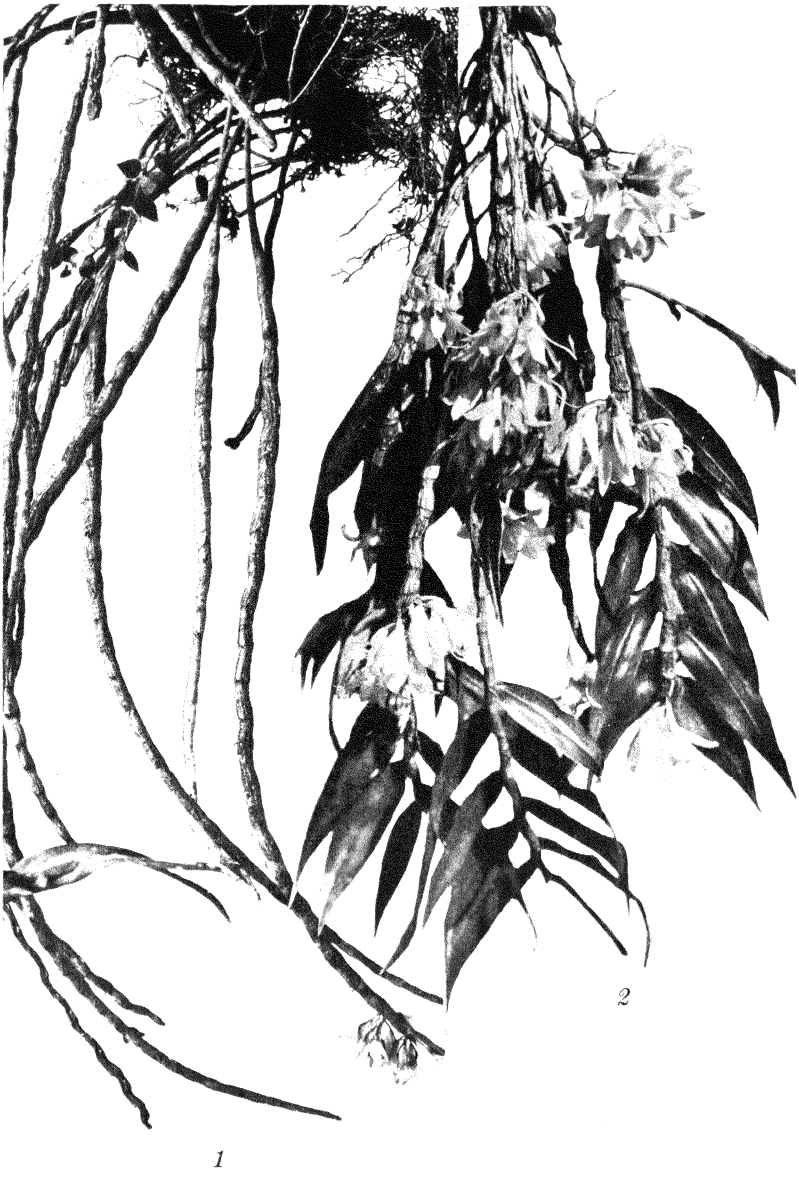

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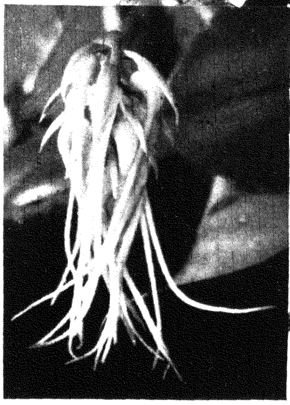

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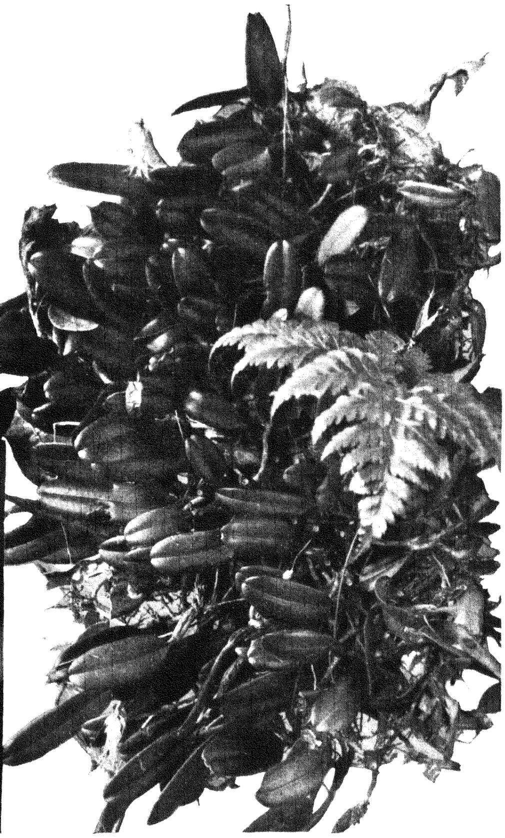

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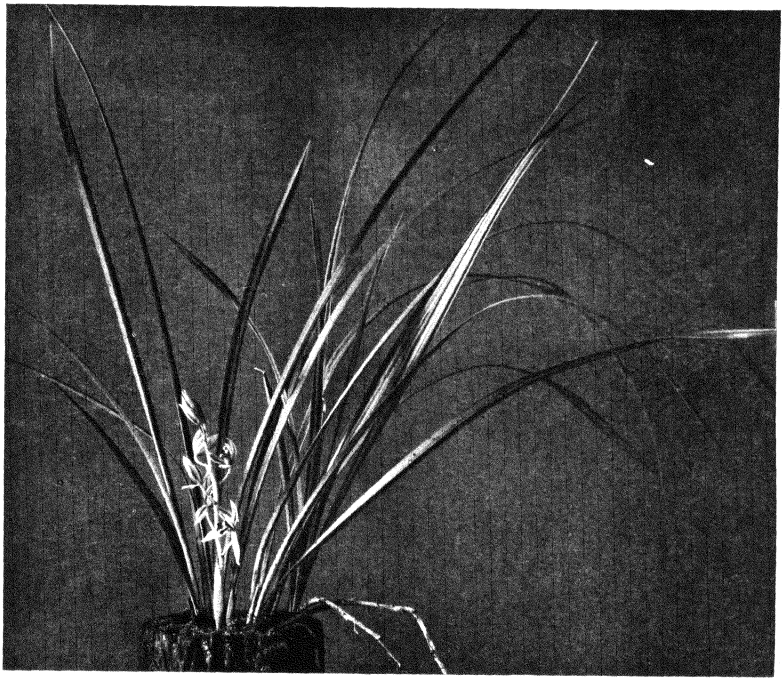

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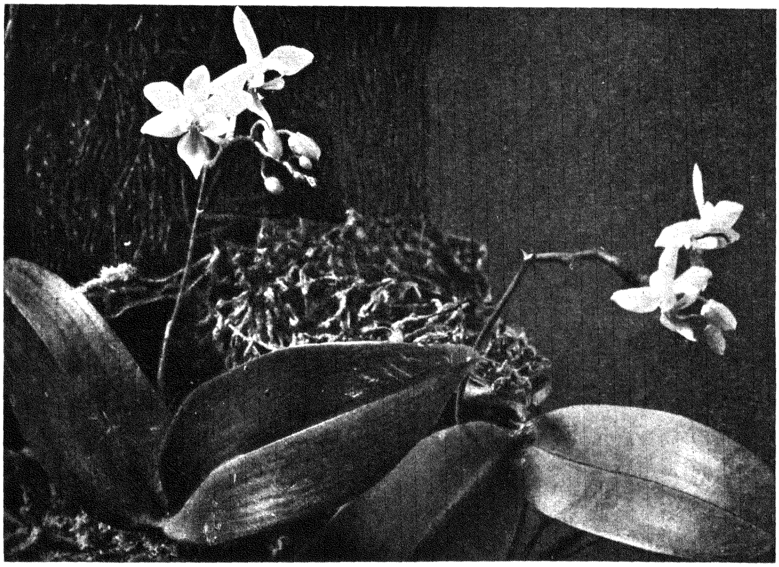

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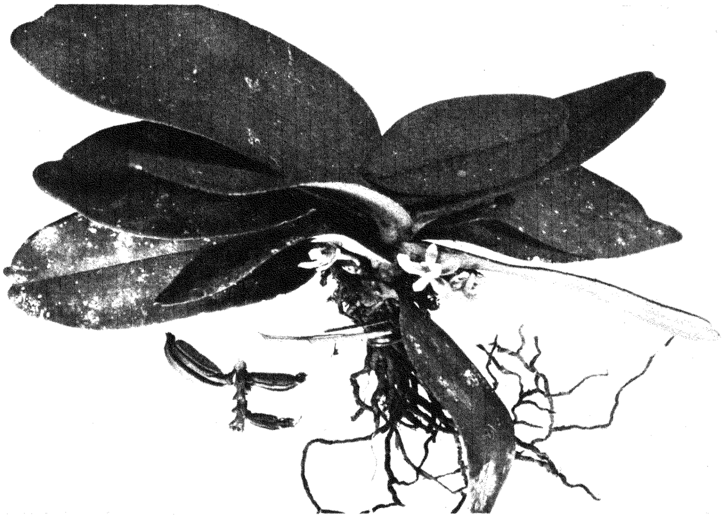

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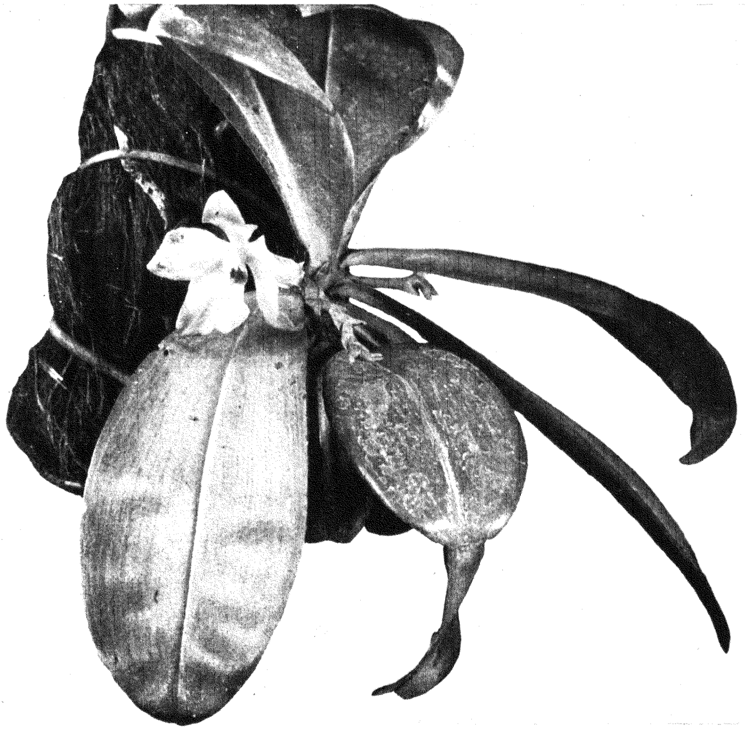

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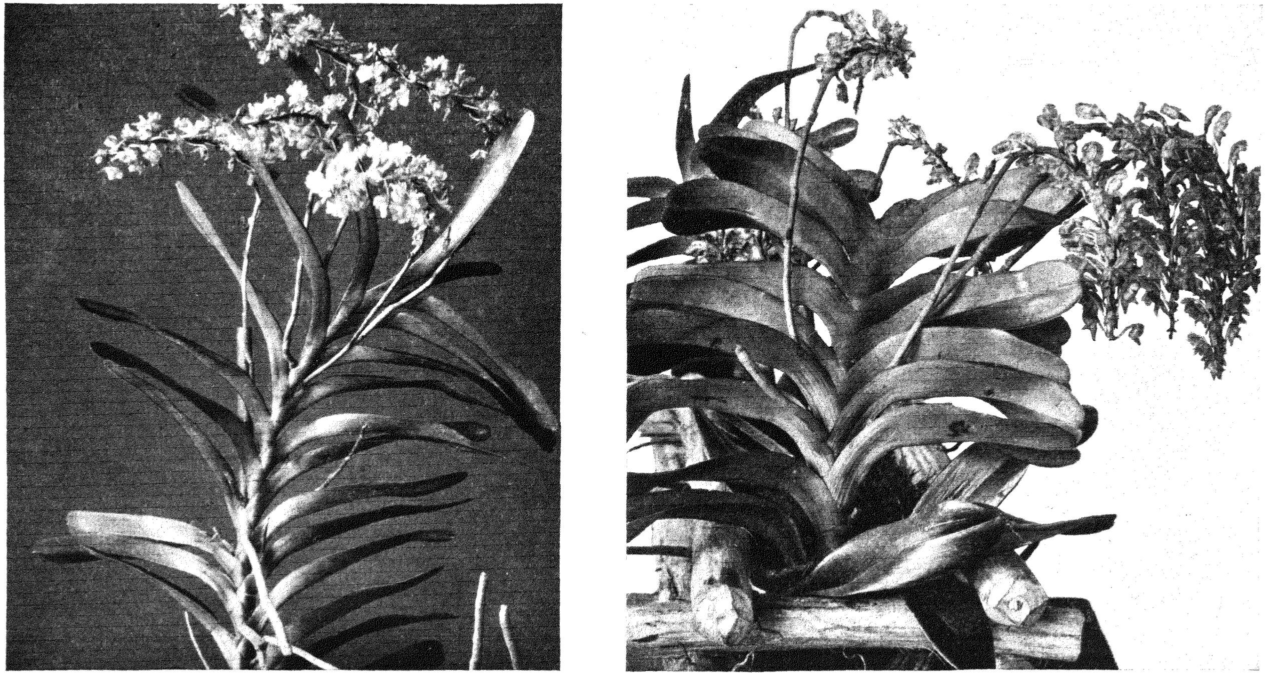

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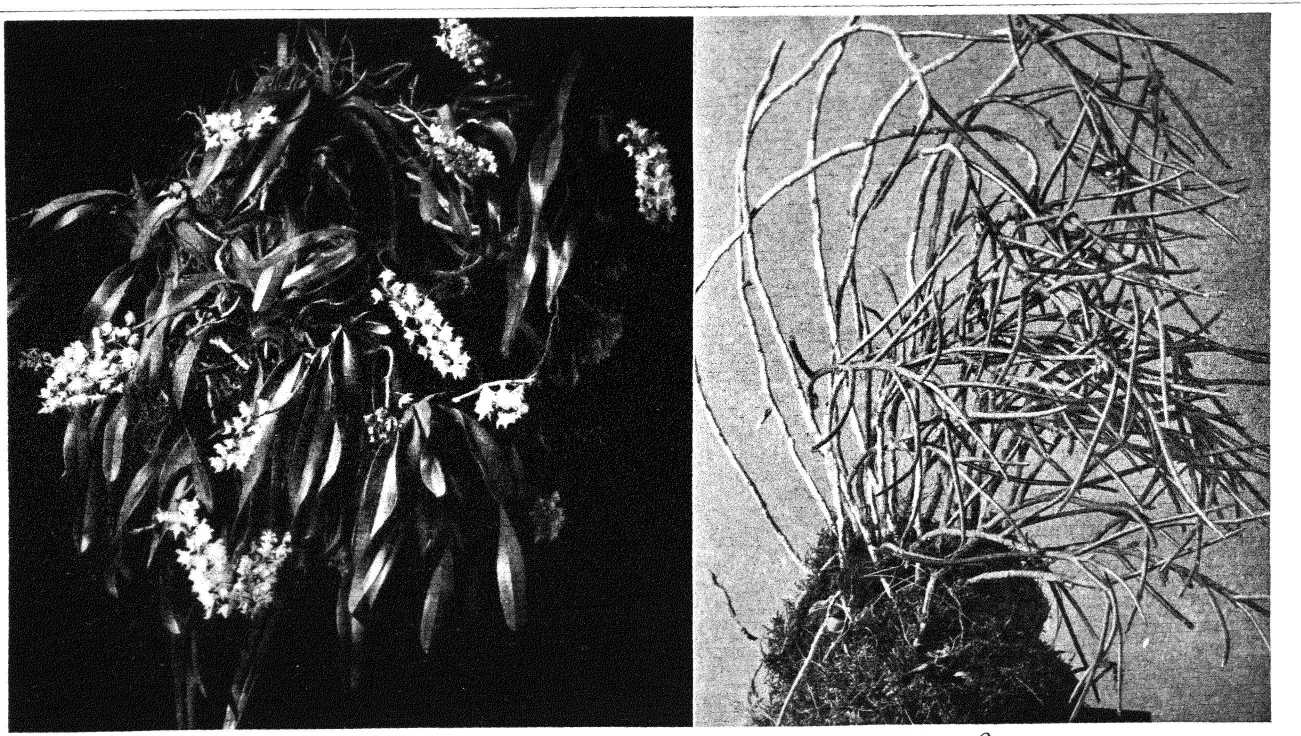

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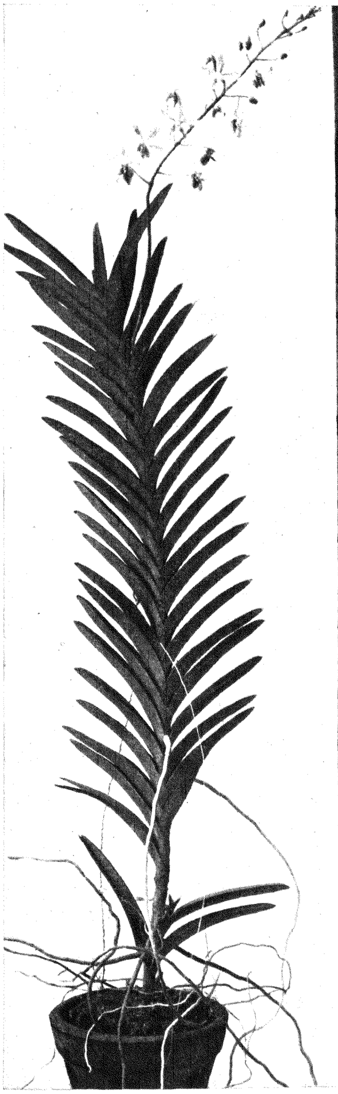

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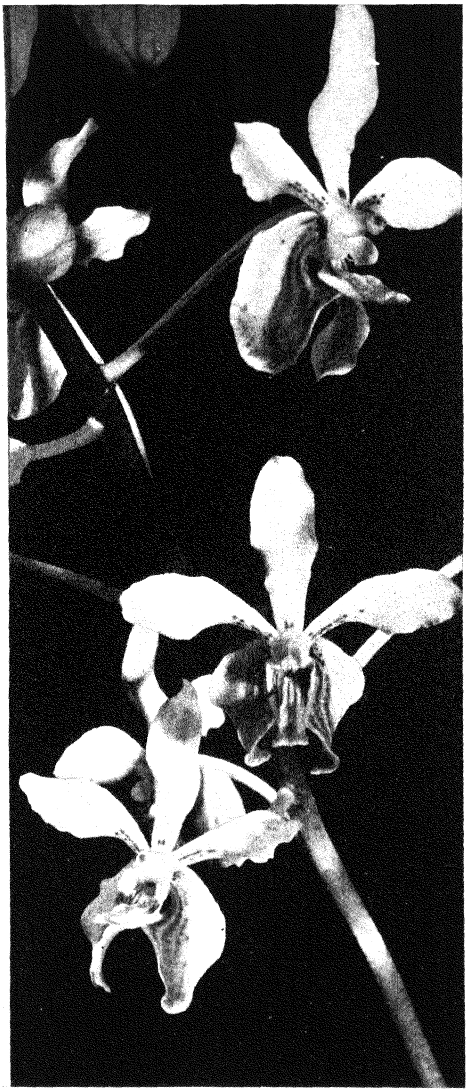

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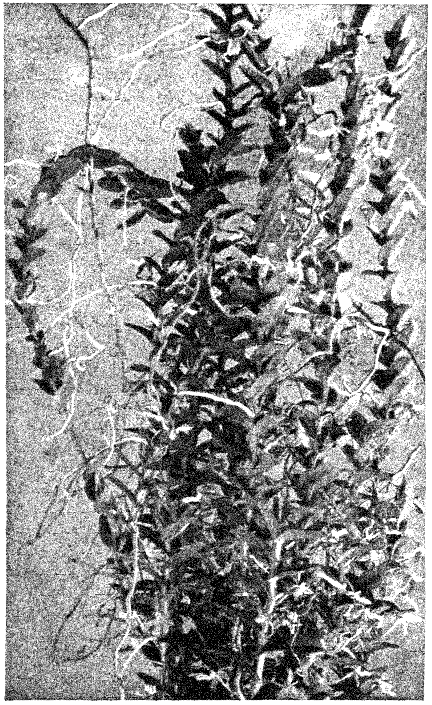

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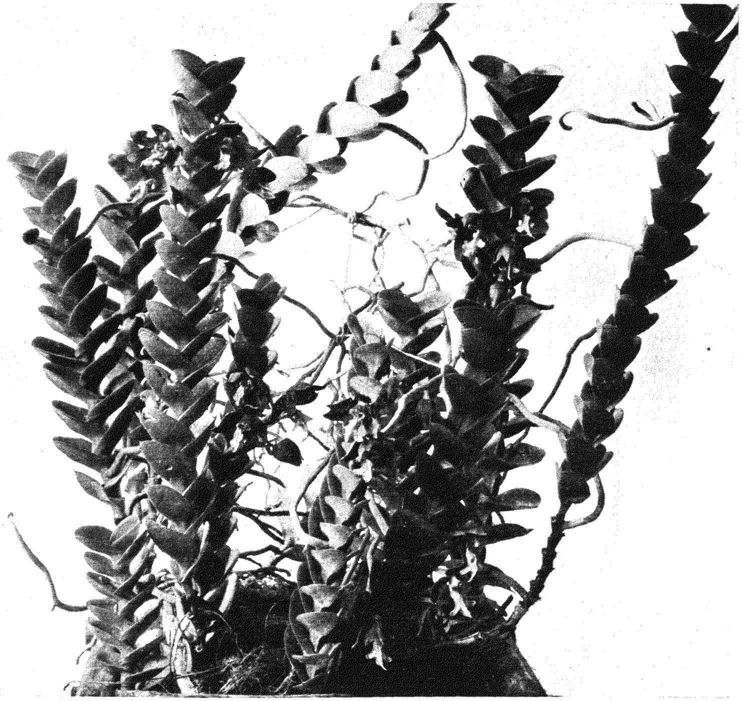

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PLATE 16.

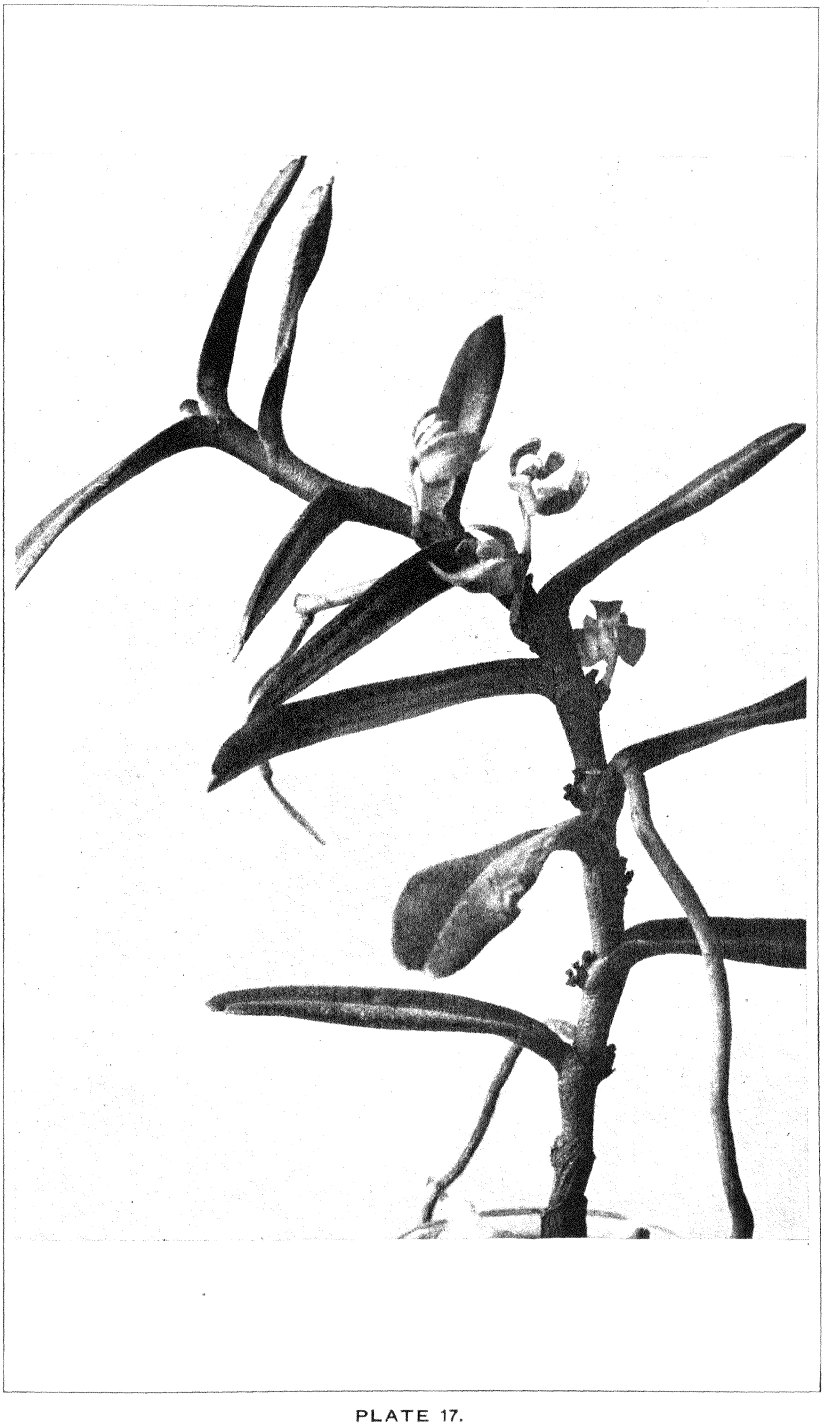

PLATE 17.

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MORPHOLOGY OF THE FLOWER AND MATURE GRAIN OF PHILIPPINE RICE

By José K. Santos

Of the Department of Botany, University of the Philippines, and of the Bureau of Science, Manila

SEVEN PLATES AND FIVE TEXT FIGURES

The rice plant (*Oryza sativa* Linnæus) has been investigated extensively as to its external morphology, classification, water and mineral requirements, experimental selection, breeding, nutrition, and nutritive properties. However, little is known concerning the internal structure of the rice plant, particularly the spikelet and mature fruit (caryopsis). Recently, some interesting data along this line were obtained, the results of which are recorded in this paper.

A survey of the available literature referring to this subject reveals that the only published accounts, as far as the writer is aware, are those of Weatherwax,(16) Robbins,(7) and Haan.(3)

Weatherwax,(16) in discussing the spikelets of six genera of Oryzæ, states that in rice the lemma has five vascular bundles and the palea only three, instead of three in the lemma and two in the palea, as previously reported by Hitchcoek. Robbins(7) indicates in his textbook on crop plants that in the cross section of the rice grain the layers are very similar to those of wheat. That is, they consist of the pericarp of several layers, the testa, the nucellus (perisperm), and the aleurone layer.

It apears that Haan(3) was the first to make a detailed study of the internal morphology of rice. He worked out not only the microscopical structure of the essential parts of the spikelet and mature rice grain, but also the structure of the leaf, stem, and root. However, in his description of the parts of the spikelet, apparently no mention is made of the structure and number of vascular bundles in the lemma and in the palea. Furthermore, his descriptions are by no means complete. A further study of the spikelet and mature rice grain therefore seems desirable.

MATERIALS AND METHODS

The young spikelets used in the detailed study of the flowering glume, palea, and ovary wall were obtained from the inflorescences of the variety kinampupoy, collected by Mr. Eulalio Gutierrez in November, 1932, at the Alabang Rice Experiment Station, Rizal Province, Luzon. The inflorescences were gathered during and after the period of pollination. All the mature spikelets were also obtained at Alabang by Mr. Gaudencio Reyes, formerly of the Bureau of Science, now of the Bureau of Plant Industry.

The materials used for studying the structure of partially as well as highly polished rice and commercial rice bran were obtained from a rice mill in Arayat, Pampanga Province. The pure unsifted rice bran was obtained from a mill in Parañaque, Rizal Province.

The young spikelets were held between pieces of the dried pitch of *Manihot utilissima* and cut from 15 to 30 μ in thickness by means of a sliding microtome. The ovaries of different stages were dissected from the spikelets, pickled with strong Flemming's fixative, washed with water, dehydrated, embedded in paraffin, and cut from 10 to 15 μ in thickness in a Spencer rotary microtome. The free-hand sections were stained with safranin and Delafield's hæmatoxylin and mounted in balsam, whereas the paraffin sections were stained with iron-alum-hæmatoxylin and mounted in balsam. The mature grain was soaked in water for about twelve hours before it was cut in the sliding microtome. It was difficult to section because the silica it contained made it very brittle. Consequently, the observations of the hull were made mostly from macerated material. For this purpose Schultze's maceration process, as described by Greenish,(2) was employed, with slight modifications, and gave fairly satisfactory results. The macerated material was examined, with or without a stain, and mounted in water, dilute glycerine, or chloral hydrate. Examinations of the rice bran were made from specimens mounted in dilute glycerine and, in some cases, in chloral hydrate solution.

For the determination and localization of the food stored in the rice grain, the following reagents were used: Tincture of alkana, 1 per cent osmic acid solution, iodopotassium iodide solution, picric acid solution (saturated), and Fehling's solution. The vegetable fatty oil is stained pink by tincture of alkana and brown by osmic acid solution; the protein matter is colored yellow or brown by a solution of iodine and yellow by picric acid; the starch grains are colored blue by iodine solution. Sugar reduces Fehling's solution, forming a reddish brown precipitate.

Some of the sections used for the microchemical detection of the food stored in the embryo were free-hand sections made by means of a safety-razor blade. The grains were soaked in water for about five hours before cutting. A grain was held between two fingers, and the razor blade applied gradually to the protruding end.

SPIKELETS

The spikelets occur in panicles and each is articulated in a minute depression in the enlarged end of the pedicel. The margin of this depression is lobed in a bractletlike structure, which if sufficiently elongated, can be mistaken for glumes. The pedicels are arranged either singly or in pairs. The spikelet is laterally compressed, one-flowered, and composed of two small glumes, a flowering glume, a palea, two lodicules, six stamens, and a pistil (text fig. 1).

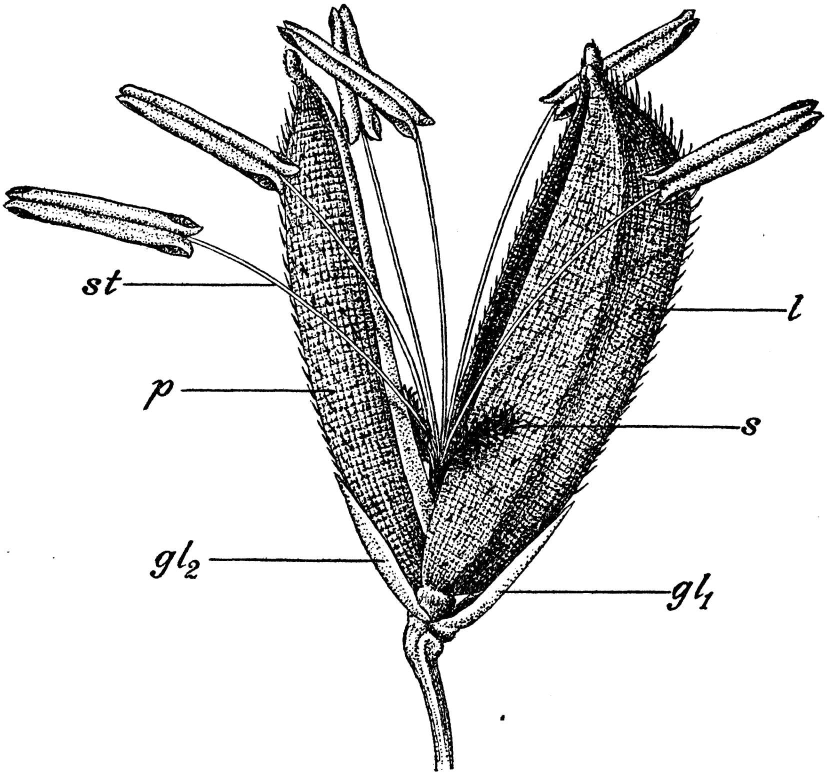
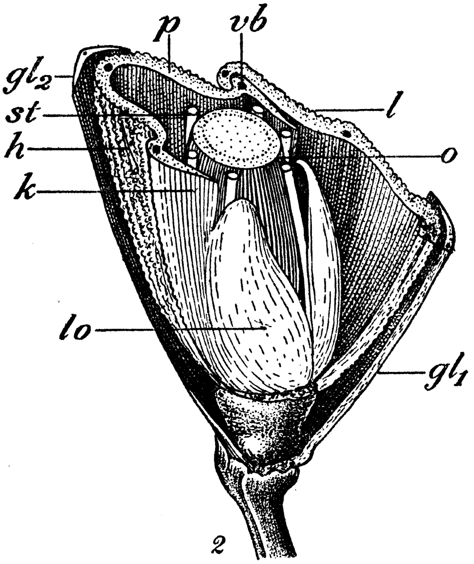


FIG. 1. An open flower of the rice variety kinampupoy; gl_1, first outer empty glume; gl_2, second outer empty glume; *l*, lemma; *p*, palea; *s*, stigma; *st*, stamen; × 10.

The first and second small empty glumes are scalelike or bristlelike. They are one-nerved, smooth and shiny on the outer surface, and whitish green or light yellowish white, which becomes ivory white in the mature glume.

The third (flowering) glume is about three times as long as the outer glumes. It is boat-shaped, five-nerved, chartaceous, laterally compressed, and light green. When it matures, however, it becomes usually pale yellowish white or straw yellow. The outer surface is somewhat rough or sandy, highly silicified, and has either few or many simple hairs. The apex is obtuse or acute.



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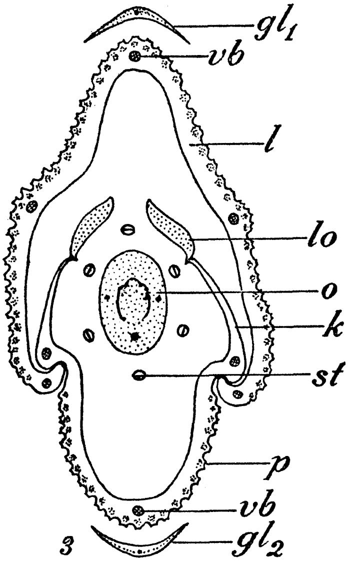

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FIG. 2. A diagrammatic drawing of a cross section of a rice flower with a portion of the lemma removed to show the relative position of its essential parts.

FIG. 3. A rice floral diagram; gl_1, first outer empty glume; gl_2, second outer empty glume; *l*, lemma; *p*, palea; *k*, keel; *lo*. lodicule; *h*, hairs; *o*, ovary; *st*, stamen; *vb*, vascular bundle.

The palea is the structure next to the flowering glume or lemma. It is very similar to the flowering glume in texture, general appearance, and color, except that it is slightly smaller, keeled, and has only three nerves. Again, at the lower ventral part of the palea, there are two minute structures, known as lodicules, which are attached to the lower edges for most of their length. These minute structures are oval or broadly oval in outline, thick and fleshy in character.

The stamens, six in number, are linear in outline, with long filaments, and split or dehisce at the lateral sides. The pistil is characterized by two plumose stigmas which are usually light yellow in color, although sometimes the color may vary from purple to red. The style is very short. The ovary is ovoid in shape and has one ovule attached at the lateral and lower side of the ovary wall opposite the lowest and small empty glume.

The rice flower opens slowly in the morning, usually between 9 and 11 o'clock, and the first parts of the flower to appear are the stamens. As soon as the lemma and palea become extended in their full length, they open and the stigmas protrude. This phase is immediately followed by the bursting of the anthers, and pollination takes place. Soon after pollination the stigmas draw back between the palea and lemma, although in some cases they remain protruding outside.

The blooming period of the rice flower and the length of time it remains open have been observed to differ with the variety, country, and climatic conditions.

In India, Sharngapani (10) observed that early paddy (*aus*) rice sown in April and May blooms in July and August and the flowers open about 7 a. m. The transplanted paddy (*sail*) rice blooms in October, and the flowers open at about 9 a. m. Hector (4) observed that in lower Bengal during May and June the rice flowers usually begin to open between 7 and 8 a. m., and continue until about 10 a. m. In late October and early November, the flowers begin to open two hours later and continue until noon. Thompstone (14) noted that in upper Burma as in India the opening of rice flowers usually occurs between 7 and 10 a. m. Stok (11) states that in Java the greater number of rice blossoms open between 10 and 12 a. m., although in some cases they open between 9 and 10 a. m. and between 12 and 1 p. m. Jones (5) reported that in California the rice flower opens between 12 and 2 p. m. On the other hand both Torres (15) and Rodrigo (8) in the Philippines observed that the rice blossoms generally open between 9 and 11.30 a. m.

As to how long the rice flower remains open, Hector (4) found that among the varieties that bloom early in the season the flowers seldom remain open longer than half an hour, while in late varieties they remain open from one to one and one-half hours. Rodrigo (8) claims that the flower of the binicol variety of rice remains open 54.7 minutes on the average, the inintiw variety 48 minutes, and the binambang 55 minutes.

The closing of the flower is also gradual. The edges of the lemma are brought slowly in contact with those of the palea until they curl up slightly and roll about each other as shown in text figs. 2 and 3. With a mature spikelet the edges of the lemma and palea become strongly and firmly fastened to each other, forming the hull, so that it is very difficult to separate one from the other without cracking a fragment of the lemma or palea. From an ordinary examination of the two structures that constitute the hull of the rice grain it apears that they are intimately united as if the hull were made up of a single continuous piece; however, in a cross section of the spikelet, it is readily observed that the edges of the lemma are simply hooked or inserted tightly into the sides of the palea.

During the ripening period there are notable changes in the appearance and structure of the spikelet. The first change observed is that the spikelet becomes stouter and turgid and the color changes gradually from pale green to dark green. This change is probably due to the resorption of some of the contents of the several layers of the ovary wall and their subsequent compression due to the enlargement of the endosperm through which the chlorophyllous layers become more conspicuous. At this (milky) stage the embryo is fully developed and the endosperm cells are filled to capacity with a watery sap. Numerous starch grains are suspended in this sap, and when the spikelet or grain is squeezed it exudes a white, milky juice.

In the next stage of ripening the spikelet begins to change gradually from green to yellowish white or straw color, and the endosperm becomes tough and waxy. Soon after that the spikelet acquires a yellowish white color. Due to loss of water the hull contracts and the different cell layers become considerably distorted and compressed. As a result the spikelet gradually develops into a hard, firm grain.

The mature grain of the variety kinampupoy follows the outline, or shape, of a closed flower (spikelet) except that it is thicker, due to the development of the endosperm (text fig. 4). It varies from 6.5 to 9 millimeters in length, from 3.2 to 4 millimeters in width, and from 2 to 2.6 millimeters in thickness. It is yellowish white or straw colored. Some rice varieties, however, show variation in color. They may be reddish brown, orange, purplish black, etc.

The fruit, or grain proper (kernel), is inclosed within the hull, which is formed by the lemma and palea tightly fastened to each other (text fig. 5). When this outer covering (hull) is carefully removed the grain appears to correspond more or less to the shape of the spikelets. It is oblong-oval and, in cross section, appears elliptical. In some rice varieties the fruit has a more-rounded form and in certain others it is more elongated.

The outer surface of the fruit (kernel) of kinampupoy is generally smooth and glistening. It has two longitudinal parallel ridges on each of the flat surfaces. On one side of the lower part there is a sort of slanting shallow cavity where the embryo is located. This is found opposite to the lowest and small empty glume. The rice kernel is surrounded by a filmlike structure which corresponds to a pericarp together with the seed coat in an ordinary dicotyledonous fruit. The color of the rice kernel depends upon the color of this filmy covering. In most cases this covering is transparent, whitish, or very light cream in color; in some cases it is red and in others violet-black or purplish black. In the kinampupoy and macan varieties the color is either transparent and white or reddish brown. A majority of the grains of the common varieties of rice are glistening and transparent, usually with a chalky white portion at the middle ventral side, known as abdominal white. The transparent characteristic of the grain is due to the glassy, or transluscent, waxy

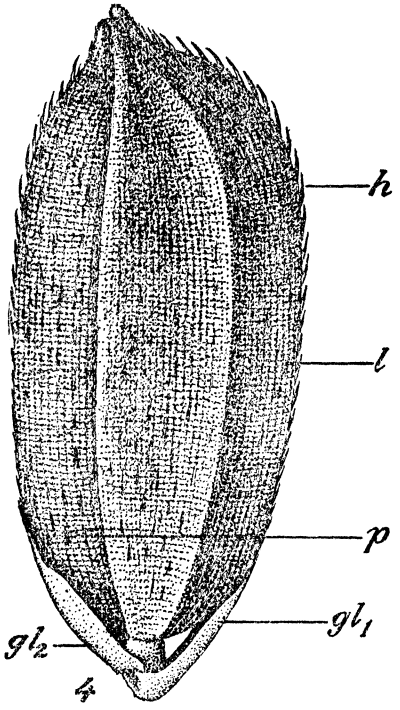

FIG. 4. A habit drawing of a kinampupoy rice grain; gl_1, first outer empty glume; gl_2, second outer empty glume; *l*, lemma; *p*, palea; *h*, hair; × 10.

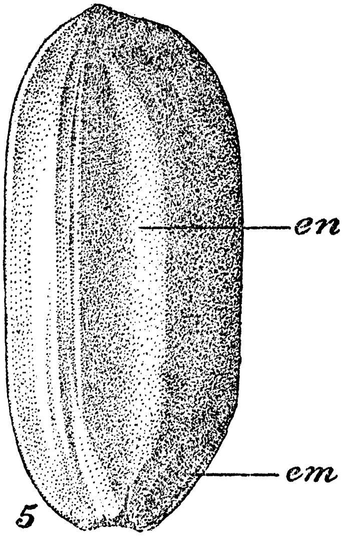

FIG. 5. A habit drawing of a kinampupoy rice kernel; *en*, endosperm; *em*, embryo; × 10.

white property of the endosperm. The abdominal white is generally very distinct in the short and coarse grains of the Philippine varieties of rice. Usually it occurs along the edge of the ventral side and approaches the center and sometimes extends even to the peripheral side of the grain. In the case of fine slender grains, however, it usually appears only slightly or is entirely inconspicuous.

MICROSCOPIC STRUCTURE OF THE SPIKELET

A thin cross section of the young spikelet (flower) shows that the outer part (immature hull) is more or less elliptic and wavy in outline and consists essentially of two parts; namely, lemma and palea. The lemma simulates the inverted italic letter *V* and the palea the inverted letter omega Ω. The lemma and palea are united by the interlocking of the free ends (text figs. 2 and 3, and Plate 3, fig. 29). The lemma is decidedly larger than the palea. It has a dentate margin and five vascular bundles. The principal vascular bundle is located at the middle of the lemma. It corresponds to the vascular bundle of the midrib in a cross section of a leaf. Two vascular bundles are located in the lateral part of the lemma and the remaining two are situated close to the ends. The free ends of the lemma are bent inward in the form of hooks. The palea also has a dentate margin but only three vascular bundles, one in the middle and two at the base of the keels.

The lemma is almost uniform in thickness, measuring about 0.12 millimeter. The outer part is limited by large epidermal cells, which have very thick walls that are somewhat corrugated, slightly lignified, pitted, and siliceous. The outer surface is lined up or protected by an irregular, thin and dentated silicate substance (Plate 2, fig. 12). In the surface view the epidermal cells are very characteristic, and they are arranged in axial rows with unicellular, simple hairs regularly distributed among them. Plate 2, fig. 14, shows a portion of the surface view of the characteristic epidermal cells of the lemma with one simple hair. The epidermal cells are dentately parted at the lateral sides and their walls border on each other (Plate 2, fig. 15). The sharp, elongated, small teeth are interlocked with those of the lateral neighboring cells in such a way that they grasp each other. The simple hairs are observed to be evenly distributed at regular intervals and are inserted between the epidermal cells. They vary in length. The hairs on the dorsal part are larger than those scattered on the lateral surface. When young, these hairs appear to have thin walls near the tip and thicker walls toward the base; but as they get older, their walls become very thick throughout, lignified, silicified, and their cavity is considerably reduced in size. Just beneath the remarkable epidermal cells there are two or three layers of five- or six-angled sclerenchyma cells with thick, slightly lignified and silicified cell walls. In the longitudinal, or in macerated sections, these cells vary in length as well as in width. Haan(3) calls them hypodermal cells. The outermost layer of the sclerenchyma, or hypodermal, cells are in contact with the lower surface of the epidermal cells, and these outer cells exhibit very characteristic, minute outgrowths, or teeth, on one or two sides. These teeth are adjusted with the pits or corrugations of the epidermal cell walls. The sclerenchyma cells in the interior do not, however, have these teeth and are entirely smooth. The inner region of the lemma is occupied by two or three layers of tangentially elongated and slightly pitted parenchyma cells. These cells are bounded in the innermost part by a layer of remarkably large, thin-walled hyaline and empty, parenchyma cells called epithelium. In the mature grain these epithelial cells are completely pressed down and therefore inconspicuous or indistinguishable. Over the surface of these epithelial cells there are a few thin-walled, mostly two-celled hairs and some stomata. The stomata are composed of two bean-shaped guard cells surrounded by large subsidiary cells.

The vascular bundles of the lemma are very simple in structure and not well differentiated. The phloëm region consists of undifferentiated, small, thin-walled conducting cells, while the xylem region is composed of small, somewhat thick-walled vessels. A segment from the midrib of the lemma (Plate 2, fig. 21) shows the characters of the epidermal cells and the simple structure of the vascular bundle. This region usually is wider than the lateral portion of the lemma. The parenchyma region consists of six or seven layers of tangentially elongated parenchyma cells. On the same plate (fig. 17) can be seen a segment of a cross section from the lateral part of the lemma.

When the lemma was macerated with nitric acid and potassium chlorate the different tissue elements were separated from one another. The most conspicuous type of cells observed were the characteristic epidermal cells, the sclerenchyma and parenchyma cells, and the fragments of the hairs (Plate 5, fig. 43, *a–g*). The epidermal cells are deeply dentated and vary from 0.06 to 0.09 millimeter in length and from 0.05 to 0.12 millimeter in width. The sclerenchyma cells are of two types; namely, the sclerenchyma cells with one or two rows of teeth or outgrowths and the plain sclerenchyma cells (without teeth). The sclerenchyma cells with teeth vary in length from 0.2 to 0.61 millimeter and those without teeth from 0.2 to 0.65 millimeter. The parenchyma cells are of two kinds. Some are elongated and have thick walls with a wavy outline and some are short and have thin walls. The hairs are usually found in fragmentary form of varying length.

The structure of the palea is very similar to that of the lemma, except that the region of the midrib is usually slightly thicker (measuring about 0.16 millimeter) and the middle vascular bundle is more differentiated than the corresponding vascular bundle of the lemma. The vascular bundle of the palea exhibits approximately the structure of a typical monocotyledonous vascular bundle. The bundle sheet and the two slightly large vessels are somewhat conspicuous, but the phloëm region is not differentiated distinctly into sieve tube and companion cells; moreover, the air space usually observed among the ordinary monocotyledonous vascular bundle is absent. A portion through the midrib of the palea is represented in Plate 2, fig. 13. A segment taken from the lateral part of the transverse section of the palea is shown on the same plate, fig. 18. The structure of the two lateral vascular bundles of the palea is very similar to the structure of the lateral vascular bundles of the lemma; that is, they are not well differentiated. The keels, as observed in a cross section, consist simply (in the outer and inner surface) of small, thick-walled, rectangular, epidermal cells. In the longitudinal section these cells are axially elongated. The inner region of the cross section of the keel is composed entirely of one or more layers of sclerenchyma cells with somewhat thin and silicified walls.

The tissue elements found in the macerated material of the palea exhibit the same characteristic and variation as those of the lemma (Plate 5, fig. 44, *a–h*). The only difference is that the epidermal cells are slightly smaller as a whole than those of the lemma, measuring from 0.03 to 0.08 millimeter in length and from 0.02 to 0.1 millimeter in width. The sclerenchyma cells with teeth, however, vary from 0.15 to 0.63 millimeter in length and those without teeth vary from 0.2 to 0.65 millimeter in length.

The two outer small glumes, in cross sections, are very similar. Their structures are simpler than those of the lemma and palea.

They consist of outer and inner epidermis and one or more layers of parenchyma cells in the middle region. The outer as well as the inner epidermis is built up of a single layer of nearly quadrangular, thick-walled, epidermal cells. In the surface view, these epidermal cells are elongated with thick and wavy cell walls, as illustrated on Plate 2, fig. 16. In the region of the midrib of the cross sections of the two glumes there is an incipient or poorly differentiated vascular bundle.

Plate 5, fig. 45, shows the different types of cells observed in the macerated material of the two outer empty glumes. The fibers may be pitted or unpitted and vary from 0.12 to 0.25 millimeter in length and from 0.01 to 0.02 millimeter in width. The parenchyma cells, like those of the lemma and palea, are also of two kinds; some are elongated, with thick walls and wavy outline, and some are short, with thin walls.

A thin cross section of a very young fruit is somewhat elliptic in outline. The ovary wall, or the young fruit wall, is about 0.07 millimeter thick with three vascular bundles—two at the lateral sides and one at the ventral side where the ovule is attached. The outer part of the ovary is limited by a single layer of tangentially elongated epidermal cells with very delicate thin walls. The inner part is bounded by a single layer of quadrangular or rectangular thin-walled cells. The space between the two epidermal regions is occupied by about ten layers of tangentially elongated, thin-walled, parenchyma cells, the two or three inner layers of which contain chloroplastids (Plate 2, figs. 21 and 22). The vascular bundles of the ovary are very simple and rudimentary in structure. The two lateral ones are not distinctly differentiated, but simply consist of small, polygonal cells with very thin walls. The third vascular bundle, located toward the lemma where the ovule is attached, is somewhat differentiated, being composed of very small, polygonal, thin-walled cells with dense protoplasm toward the outer part, and toward the inner part having small polygonal or rounded and empty cells with slightly thicker walls.

In the longitudinal sections, the outer epidermal cells are rectangular in outline and the parenchyma cells between the inner and outer epidermis vary from rectangular to quadrangular and in some cases are polygonal. The parenchyma cells decrease in size from the outer to the inner region. The inner epidermal cells, on the other hand, are greatly elongated—about twenty times as long as their diameter. For this reason these cells, which are observed even in the mature fruit, are called tubular cells by Haan.(3) Plate 3, fig. 25, represents a segment drawn from a surface preparation of a young fruit wall, showing the distribution and characteristics of the greatly elongated epidermal cells.

The middle portion of the cross section of a very young fruit is occupied by the young endosperm, nucellus, and the inner integument. The outer integument is absorbed during the early stage of the developing embryo. Plate 2, fig. 19, represents a small segment of a cross section of a very young ovary taken through the integumental regions just before the cells of the outer integument are disorganized. On the same plate, fig. 20, is another segment of a thin transverse section also taken through the integumental region near the base of the fertilized and developing ovule. It shows a portion of the inner epidermis of the ovary wall, the basal portion of the disintegrating outer integument, the inner integument, and a portion of the nucellar region. Plate 3, fig. 23, shows a portion of a cross section, from the lateral side, through the corresponding regions shown in Plate 2, figs. 19 and 21. It illustrates the absorption of the inner nucellar cells. The inner integument at this stage consists of two layers of rectangular cells of unequal size. Those of the outer side are smaller and nearly quadrangular in outline, while the inner cells are larger, usually rectangular, and contain dense protoplasm.

Within the inner integument is found the nucellar region. It consists of large hyaline cells of varying shapes with extremely thin or delicate cell walls (Plate 2, fig. 21). The outer layer constitutes the epidermis of the nucellus, and it is composed of tangentially elongated or rectangular cells with dense protoplasm. In the longitudinal section they are either radially elongated, quadrangular, or somewhat axially elongated. The two or three (inner) remaining layers are either irregularly shaped, rounded, or tangentially elongated, with small intercellular spaces, and contain a small amount of protoplasm. In the longitudinal section they are usually axially elongated or rectangular in outline with slightly wavy cell walls (Plate 2, fig. 22). On the inner side the nucellar region is bounded by the young aleurone cells, which are tangentially elongated, have thin walls, and contain dense protoplasm. The nucellar cells, except those of the epidermis, become gradually pressed or disorganized and are absorbed by the developing embryo, as in the case of the wheat, except that the walls of the epidermal cells of the nucellus do not become thickened and lignified (Plate 3, figs. 23 and 24).

The structure of the endosperm in a cross section of a very young fruit shows that it is composed usually of polygonal or irregularly shaped parenchyma cells with extremely thin walls and contains a moderate amount of protoplasm. The outer part is limited by a layer of tangentially elongated thin-walled cells with denser protoplasm. This layer constitutes what is called an aleurone layer, for in the mature grain it contains a considerable amount of aleurone grains of proteins, and fatty oil (Plate 2, figs. 19 to 21). In the longitudinal section the endosperm cells also vary in outline. They are usually either polygonal or radially elongated as shown on Plate 2, fig. 22.

During the fertilization stage the ovule is rather small and somewhat separated from the ovary wall, but soon after fertilization the increase in size of the ovule is remarkable. The embryo sac is gradually filled up by the developing endosperm and embryo. While the size gradually increases the loose cells of the covering of the ovule are pressed together flatly. The only cells that remain unpressed are those that contain dense protoplasm, as, for instance, those of the epidermis of the nucellus and of the inner integument. At this stage the cells of outer integument begin to disorganize and finally disintegrate (Plate 2, figs. 19 and 20). As the young grain is ripening or maturing it continues to increase in size until the nucellar region and the cells of the inner integument are pressed flatly against the pericarp, and this in turn against the wall of the hull. Thus the filmy covering of the mature rice grain is composed of the pericarp, the inner integument or testa, and the nucellus or perisperm. These are all strongly pressed together into a very compact form in which the individual structure of the different tissue cells is lost. Because of this fact the filmy covering of the rice grain appears of one piece, as if derived from a single structure.

The color of the rice grain depends upon the color of the filmy covering, called by Haan(3) a silverfilm. The coloring matter is found in the inner layer of the testa.

The mature endosperm constitutes the kernel of the rice grain proper. In a thin cross section it appears more or less elliptical, the outer part being limited by the aleurone layer (Plate 3, fig. 29, and Plate 4, fig. 34). The aleurone layer is composed of a single layer of quadrangular or rectangular parenchyma cells with thin walls. These cells are filled up with small protein granules and some droplets of fatty oil (Plate 3, fig. 28). Within the aleurone layer at the dorsal side there are two short layers of polygonal parenchyma cells, which also contain some protein granules and droplets of fatty oil (Plate 4, fig. 34). The endosperm is built up of thin-walled parenchyma cells, which are generally elongated radially, and heavily loaded with starch grains and some protein granules. Those that are found toward the flattened or lateral sides are either polygonal or slightly elongated, but those that are extended from the ventral to the dorsal side are greatly elongated. The endosperm cells in the sector toward the ventral region, which corresponds to the part occupied by the abdominal white, contain practically only starch grains. A critical microchemical test shows that the protein contents of the endosperm cells mixed with the starch grains decrease proportionally from the periphery toward the region of the abdominal white. The starch grains are elliptical, oval, or nearly spherical, and measure from 0.015 to 0.055 millimeter in length and from 0.012 to 0.035 millimeter in width (Plate 5, fig. 46). They are composed of many-cornered (polyedric) grainlets, measuring from 0.003 to 0.008 millimeter. The sides of these grainlets fit in with, or are adjusted to, each other, but those at the outer part, or periphery, are convex.

The rice embryo is relatively small. It is only about one-third the length of the fruit and it is located near the base, toward the lemma or ventral side of the grain.

In the longitudinal section of the grain, cut parallel to the flat side, the embryo appears more or less lenticular in outline. In the middle part the plumule and primary root are arranged in the form of a capital L; that is, the plumule corresponds to the longer vertical arm, while the primary root corresponds to the short horizontal arm. These are joined to each other by a short stem, more or less at right angles, and embedded or surrounded by a mass of thin-walled polygonal parenchyma cells, which form the scutellum, epiblast, and coleorhiza as represented on Plate 3, fig. 26. The ventral side of the embryo is protected by the prolongation of the aleurone region from the upper part of the embryo to the base and serves as an epidermis. This epidermis in turn is covered by the pericarp, which is pressed together with the seed coats. The same plate (fig. 27) represents another diagrammatic, median, lengthwise section showing the structure of the embryo. In this diagram the primary root is almost rounded in outline and surrounded by a mass of soft tissue, known as root sheath or coleorhiza.

The plumule, or the primary bud, is somewhat ovate in outline, pointing obliquely away from the apex of the grain. It is composed of a minute growing point, one or more foliage leaves, and a coleoptile. The growing point is the region surrounded by one or more immature foliage leaves, which are attached to the upper end of the hypocotyl. The leaf sheath, or coleoptile is the structure that incloses the growing point and the foliage leaves. The plumule is bounded at the inner side by a specialized structure, the scutellum or cotyledon, which lies next to the endosperm and is attached to the hypocotyl. At the region where the root sheath merges into the hypocotyledonary tissue there is a projecting structure, which extends toward the upper end of the tip of the plumule and overlaps with the upper end of the scutellum. This projecting structure, devoid of vascular tissue, is known as epiblast. In the case of wheat, the epiblast is greatly reduced in size and, according to Robbin,(7) it has been suggested that the scutellum and epiblast represent two cotyledons; one, the scutellum, is highly modified, while the other, the epiblast, is suppressed. Between the plumule and the primary root there is a very short stem, called hypocotyl, which terminates at the anterior end in a stem-growing point, and at the posterior end extends into the primary root.

A critical microscopical examination of the embryo shows that, in a longitudinal section, the plumule and the primary root are composed of thin-walled parenchyma cells with square, polygonal, or elongated outline (Plate 4, figs. 40 and 41). These are surrounded by epithelial cells, which are also somewhat radially elongated. The parenchyma cells of the plumule and the primary root, together with the corresponding epithelial cells, are filled with minute protein granules and small droplets of fatty oil. The outermost layer of the scutellum, toward the endosperm, consists of radially elongated thin-walled parenchyma cells, which are arranged somewhat in a palisade form (Plate 3, fig. 30, and Plate 4, fig. 42). This layer is known as epithelium. The epithelial cells are filled with minute protein granules and small droplets of fatty oil. They extend to the base, to the stem, and to the coleorhiza.

The inner cells of the cotyledon, in cross or longitudinal sections, appear to be polygonal and of varying size. They have very thin walls and are filled with minute protein granules and small droplets of fatty oil. The cotyledonal cells toward the seed coat are somewhat larger than the inner cells and those of the outermost layer are tangentially elongated (Plate 3, fig. 31). During germination the scutellum remains with the endosperm and serves as an absorbing and conducting organ for the material from the endosperm to the growing regions. The epiblast, like the scutellum, is composed of thin-walled, rectangular or polygonal parenchyma cells containing proteins and fatty oil. It is surrounded by an epithelium. Plate 3, fig. 30, represents a segment of a thin section (highly magnified) through the outer region between the scutellum and endosperm. It shows their relative positions, their cellular contents, and the extension of the aleurone region to the outer surface of the embryo. On the same plate is another segment (fig. 32) from a thin section in the outer and lower region of the apical part of the scutellum. This segment indicates the relation between this part of the scutellum and the portion of the upper part of the epiblast and shows how they are held together by the extension of the aleurone layer. On the same plate fig. 33 represents another segment from the basal part of the grain. It shows the relation between the endosperm and the coleorhiza as covered by the extension of the aleurone layer.

Structure of the polished rice grain.—The polished rice grains (kernels) are slightly smaller in size than the unpolished ones and generally some are cut either into two equal or unequal parts. Their outer surface is smooth, nonglistening, waxy white, and with or without prominent chalklike abdominal white. The two parallel ridges on each of the flat surfaces are inconspicuous. The embryo is usually removed or knocked off during the polishing of the grains, as illustrated on Plate 1, fig. 11. A thin transverse section of the polished rice kernel shows that in the process of polishing not only the pericarp, seed coats, and embryo are removed but also most of the aleurone layer, which is the region of the rice grain containing proteins and fatty oil. Plate 4, figs. 35 and 36, are reproduced from thin transverse sections of polished rice grains of the macan and elon-elon varieties. On the same plate, figs. 37 and 38, are two highly magnified segments from a transverse section of the elon-elon variety. As shown by the drawing in fig. 37, not only the aleurone layer is removed, but also a portion of the outer layer of the endosperm cells. Figure 38 shows a segment taken from the groove region, where a small portion of the aleurone layer is left. Plate 4, fig. 39, represents a segment from macan variety corresponding to that of fig. 38, in which a very small portion of the aleurone layer remains after the polishing. It is quite evident, therefore, that in polished rice, the embryo and most of the aleurone layer are removed. The polished rice is, therefore, much less nutritious than the unpolished.

Rice bran.—The portion of the grain removed during the polishing of rice is called rice bran. It is also known as darak, tikitiki, or rice polishings. The bran consists of fragments derived from the pericarp and seed coats together with a greater portion of the aleurone layer, part of the endosperm, and the embryo. Sometimes the bran contains particles of rice hulls that got into the bran accidentally or have been purposely added. The shape and size of the fragments and even the components of the rice bran vary according to the rice mill in which the rice bran is produced. The quality of the rice bran depends upon the amount of the fragments derived from the hull and from the two small outer glumes. However, when the rice bran is carefully prepared, especially by the modern type of rice mill, it is almost entirely free of hull fragments. An examination of a sample of rice bran obtained from a rice mill in Rizal Province showed that it consists entirely of the fragments of the pericarp adhering to the seed coat with the aleurone layer, endosperm cells with starch grains, the embryo, and some small fragments of hairs (Plate 6, figs. 47 to 53). A microchemical test of rice bran shows it to be very rich in protein, fat or fatty oil, starch, and soluble carbohydrates contained in fragments of the embryo. As the fragments from the pericarp and testa are compressed into a compact form, the cells are empty and apparently without nutritive substances. It is quite evident, therefore, that the vitamins found in the bran (tikitiki) extract are derived from the embryo and the aleurone region of the rice grain. Plate 7, figs. 54 to 61, represent the fragments of rice bran improperly prepared and containing some rice hulls.

Microchemical tests.—The microchemical investigation on the mature rice grain and the rice polishings (rice bran) was limited to the determination and localization of the substances that have direct bearing on its nutritive value as human food. That is, the starch, protein, fat or fatty oil, and other carbohydrates. A thin cross section of the kernel was treated with a dilute solution of iodopotassium iodide. The contents of all the endosperm cells were thus stained blue, except those of the aleurone layer. This indicates that the greater part of the contents of the endosperm cells consists of starch grains. A closer examination of the treated section also shows that between the starch grains and especially near the sides of the cell walls there are very minute granules stained yellow, or brownish yellow, by the iodine. These yellow-colored granules are protein substances. Large quantities of similar granules fill the greater part of the cavity of the aleurone cells. When another section was treated with a saturated solution of picric acid, the granules (previously stained brownish yellow by the solution of iodopotassium iodide) became yellow, while the starch grains remained colorless. This proves conclusively that the protein substance is contained largely in the aleurone cells and in comparatively smaller amounts in the endosperm cells. On the other hand when another cross section of the endosperm was treated with freshly prepared tincture of alkana only the fat or oil globules in the aleurone cells were stained a pink or reddish color. The oil globules were colored brown also when treated with 1 per cent osmic acid. In some other sections Fehling's solution was applied, but no positive results were obtained. Transverse and oblique sections through the embryo were also treated in the same manner. It was found that the cells of the aleurone region, the scutellum, the plumule, and the radicle contain a considerable amount of protein substances and oil globules. Moreover, when some sections from the embryo were treated with Fehling's solution, a reddish brown precipitate was observed. This shows that the embryo is not only rich in protein and oil, but also contains some soluble carbohydrates. Since the rice bran generally is derived from the aleurone region, endosperm, pericarp, seed coats, and embryo, it is to be expected that the bran will have the substances contained in these sections. When small portions of rice bran were treated with the above reagents, which were used in the sections, it was found that the fragments derived from the embryo consist mostly of proteins, fatty oil, and soluble carbohydrates. Those from the aleurone layer contain these same substances except the soluble carbohydrates. The fragments derived from the endosperm showed positive reactions for starch and proteins. The pericarp, seed coat, and fragments of the hull did not react to the different reagents, except when they were contaminated with the substance of the fragments derived from the aleurone region, endosperm, and embryo.

Microchemical tests were also made on the section of the lemma and palea, but no positive results were obtained.

DISCUSSION OF RESULTS

With definite varieties of rice the flower parts of a rice spikelet are usually constant. The individual flower parts in different rice varieties show much diversity in various features; namely, size, shape, color, tips, surface outgrowth or hairs, etc. The great variations among the grains of the different rice varieties are due to the modifications of the flower parts, some of them simply acquired, but most of them hereditary. Some of these characters have consequently been used by several authors in the attempt to classify rices. During the last two decades they have been, and still are, important subjects for genetic investigation by rice breeders.

The outer glumes generally are small, smooth and shiny, but in one well-known variety in the Philippines (pirurutong) they are large, almost equalling or, in some cases, exceeding the lemma and palea in length. The young lemma and palea, which represent the inner glumes, are usually light green and with or without a dark purple spot at the apex; upon ripening they become yellowish white or straw-colored. In some cases, however, they may be orange, red, brown, purple, or nearly black with many different shades. The apex of the flowering glume or lemma is ordinarily obtuse or acute, although in some cases it is provided with a hard bristlelike prolongation of varying length and color and known as "awn." Kikkawa(6) claims that most of the prevalent varieties in advanced centers of rice culture are awnless. Sethi and Saxena,(9) on the other hand, observed that awns are generally found in coarse types, and that wild uncultivated types and usually those grown in some swamps also show abundant production of awns. This observation seems to agree with some of the Philippine rice varieties; such as, *lampadan, pirurutong, igorot, pasayan, mambog II, mantica, uuac, paringayod, maralesa, dekita lacay, gracia, madre de casa, marapa, sinamporin,* and many others.

The size and the shape of the rice grain (caryopsis) differ with the variety, and therefore are important from the standpoint of taxonomy. They are useful as diagnostic characters and have been used by almost every rice taxonomist in the classification of the varieties of rices. The Philippine rice varieties exhibit a great diversity in size and shape (Plate 1, figs. 1 to 10). Some varieties have small and slender grains, others have short and broad grains, and still others have long and broad ones. Sethi and Saxena(9) distinguished three groups of grains of the rice varieties found in the United Province of India; namely, slender, long, and short. When the length of the grains is three times as great as the breadth, or more, it is called "slender;" when the length is more than twice but less than three times the breadth it is known as "long;" and when the length equals twice or less than twice the breadth it is called "short." Graham,(1) working with rices in the Central Provinces of India, divides the sizes of the spikelets into four groups, as follows:

1. *long* spikelets in which the length is more than four times the breadth,
2. *fine*, in which the length is more than three times the breadth,
3. *coarse*, in which the length is more than twice the breadth, and
4. *round*, in which the length is less than twice the breadth.

The rice kernel is generally whitish or very light cream in color, but in some cases it is red, like some of the grains of Macan I, and it may be violet-black or purplish black as in the grains of "pirurutong." In the white varieties, the abdominal white may be conspicuous or inconspicuous. This abdominal white according to Inagaki, as quoted by Kikkawa,(6) is nothing but a portion of the rice grain where spaces between the starch grains are not filled with albuminous substances. Tanaka(13) agrees with the findings of Inagaki, but he believes that the formation of the abdominal white is due to an insufficient supply of nutritive matter during the ripening time, to abnormal arrangements, or to an improper proportion of the accumulated substances in the grain. The chemical analysis made by U. Suzuki and K. Aso,(12) showed that the chalky region of the rice grain has an abnormally low percentage of albuminoids. On the other hand Kikkawa(6) states it can be said safely that the abdominal white fluctuates according to climate, weather, and method of cultivation, but its heredity is not yet determined. He believes that a similar difference of texture also exists in the glutinous rice, but because the endosperm of the glutinous rice is generally uniformly chalk-colored, they cannot be distinguished. The findings of the writer quite agree with those of Inagaki and Kikkawa.(6)

The above results of the microscopical examination of the lemma and palea confirm Weatherwax's(16) claim of five vascular bundles in the lemma and three vascular bundles in the palea. These vascular bundles are not indicated in the detailed study made by Haan.(3) The structure of the covering of the rice grain is very similar to that of wheat; that is, it consists of pericarp derived from the ovary wall, testa developed from the inner integument, and perisperm from the nucellus; the outer integument is absorbed during the development of the embryo. The only difference is that the perisperm is not made up of cells with strongly thickened walls and with indistinct cavities. Moreover, the filmy covering of the rice grain is comparatively thinner than that of the wheat, and the inner epidermal cells of the pericarp are developed into tubular cells. However, the results obtained on the development of the filmy covering agree perfectly with those of Haan(3) who called it "zilvervlies" (silver film). The color of the rice grain is due to the coloring matter deposited in the inner layer of the testa.

The endosperm is limited in the outer part by an aleurone layer filled with fat, or oil, and protein granules. It consists of thin-walled, radially elongated, parenchyma cells richly supplied with starch grains and contains a relatively large amount of protein substances.

The small embryo is somewhat similar in structure to that of wheat. It consists of a primary root, leaf sheath or coleoptile, plumule, scutellum, coleorhiza, and epiblast. It contains a considerable quantity of protein substances, fat or oil, and soluble carbohydrates, but no starch.

The bran of rice, like wheat bran, which is extensively used in bread making, includes the three outer layers of tissues; namely, pericarp, testa, and nucellus or perisperm, and also the embryo. The pericarp constitutes the largest proportion of the bran. The protein contents, fat or oil, and soluble carbohydrates of the bran, are derived from the aleurone cells and the embryo, while the starch content is derived from the endosperm cells, which adhere to the bran layers in the milling process.

Commercial rice bran consists of the fine, scalelike, flaky, outside covering of the rice kernel removed during the polishing. This is composed of the pericarp, testa, perisperm, most of the aleurone layer, some starchy endosperm, and usually the whole or fragments of the embryo. Fragments of the hull and the two outer small empty glumes, remnants of the stigma, and also portions of the lodicules may sometimes be found in the bran due to improper milling. The latter fragments are either accidentally or purposely mixed with the former fragments. Microchemical tests showed that they do not contain oil or fat, protein substances, starch, or soluble carbohydrates.

SUMMARY AND CONCLUSIONS

1. The essential parts of a rice flower, technically known as spikelet, are the following: (*a*) Two small bristlelike outer glumes; (*b*) a boat-shaped flowering glume, or lemma; (*c*) a palea, a glume similar in size, shape, and texture to the lemma; (*d*) two small, oval, thick, and fleshy structures known as lodicules; (*e*) six stamens; and (*f*) a pistil with a plumose stigma.

2. The lemma and palea are five- and three-nerved, respectively.

3. The structure of lemma and palea in transverse sections is more or less similar. Their composition is as follows: (*a*) Remarkably large epidermal cells with corrugated, thick, lignified, pitted walls and silicified or lined with silica in the outer part; in the surface view they are dentated or dentately parted; (*b*) few simple hairs between the epidermal cells; (*c*) two or three layers of sclerenchyma cells, the outer layers of which are characterized by minute outgrowths or teeth; (*d*) two or three layers of tangentially elongated and colorless parenchyma cells; (*e*) a layer of large, thin-walled, hyaline and empty parenchyma cells known as epithelium.

4. The vascular bundles of the two glumes are quite similar in structure, consisting of small undifferentiated phloëm cells and poorly developed xylem vessels.

5. Few stomata and simple hairs are found in the inner surface of the lemma and palea.

6. The young grain coat consists of (*a*) outer epidermis; (*b*) seven to nine layers of tangentially elongated, colorless, parenchyma cells; (*c*) two or three layers of rectangular chlorenchyma cells; (*d*) inner epidermis composed of a single row of small cells; (*e*) outer integument, two layers of cells; (*f*) inner integument, also two layers of cells; (*g*) nucellus built up of several layers of thin-walled parenchyma cells.

7. The mature grain coat consists of a filmlike covering composed of the following structures: The ovary wall or pericarp, the inner integument and nucellus which are pressed together flatly in a somewhat compact form.

8. The kernel is oblong oval, usually smooth and glistening, whitish or translucent waxy white, with or without abdominal white. Sometimes it is red or purplish black.

9. The endosperm is built up of thin-walled, elongated, parenchyma cells filled with starch grains and some protein substances. The outer part of the endosperm is limited by a layer of rectangular cells known as aleurone cells, which are rich in proteins and fat or oil globules.

10. The embryo is small and rich in protein, fat or oil, and soluble carbohydrates.

11. Microchemical tests showed that the aleurone cells are filled with a large amount of fat or oil and protein; the endosperm cells contain starch grains and a relatively large amount of proteins; the embryo is very rich in fat or oil and proteins,

and contains soluble carbohydrates. The pericarp, seed coat, and the hull possess no fat or oil, starch, protein, or soluble carbohydrates.

12. The rice bran consists of the fragments derived from the outer covering of the kernel. It is composed of the pericarp, testa, and the perisperm with the portion of the aleurone layer adhering to it. In addition, fragments or the entire embryo and particles of the endosperm are usually included in it, and in some cases fragments from the hull that are either accidentally or purposely mixed with the above.

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ILLUSTRATIONS

[Most of the microscopic drawings were prepared under camera lucida by the author. Some were traced by Mr. J. V. Santos and Miss Trinidad Villegas, of the Department of Botany, University of the Philippines. The habit sketches of the flower and fruit were drawn by Mr. M. Ligaya, and the photograph was prepared by the Bureau of Science.]

PLATE 1. ORYZA SATIVA LINNÆUS

FIG. 1. Hulled and unhulled rice variety *apostol;* × 3.2.
2. Hulled and unhulled rice variety *elon-elon;* × 3.2.
3. Hulled and unhulled rice variety *macan* I; × 3.2.
4. Hulled and unhulled rice variety *macan biñan;* × 3.2.
5. Hulled and unhulled, *a* and *b*, rice variety *lampadan;* × 3.2.
6. Hulled and unhulled rice variety *macan santa rosa.*
7. Hulled and unhulled rice variety *malagkit* (striped); × 3.2.
8. Hulled and unhulled rice variety *quinastila;* × 3.2.
9. Hulled and unhulled rice variety *ramay;* × 3.2.
10. Hulled and unhulled, *a* and *b*, rice variety *pirurutong;* × 3.2.
11. Polished and unpolished kernel of the rice variety *elon-elon;* × 3.2.

PLATE 2. ORYZA SATIVA LINNÆUS VAR. KINAMPUPOY

FIG. 12. A segment from the middle portion of a thin transverse section of the lemma; *e*, epidermis; *scl*, sclerenchyma; *si*, siliceous covering; *p*, parenchyma; *vb*, vascular bundle; and *ie*, inner epithelium; × 416.
13. A segment from the middle portion of a thin transverse section of the palea; *e*, epidermis; *scl*, sclerenchyma; *si*, siliceous covering; *p*, parenchyma; *vb*, vascular bundle; *v*, vessel; × 416.
14. A portion of a surface section of the epidermis, showing the remarkably deeply dentated epidermal cells, their arrangement and their interlacing between each other; *h*, hair; × 416.
15. A reconstructed diagrammatic drawing of an epidermal cell, highly magnified.
16. A portion of a surface preparation of the lower epidermis of the first outer empty glume showing the axially elongated epidermal cells with wavy, thick, and pitted walls; × 416.
17. A small segment from the lateral part of a thin transverse section of the lemma; *e*, epidermis, *scl*, sclerenchyma; *p*, parenchyma; *si*, siliceous covering; *ie*, inner epithelium; × 232.
18. A small segment from the lateral part of a thin transverse section of the palea; *e*, epidermis; *scl*, sclerenchyma; *p*, parenchyma; *si*, siliceous covering; *ie*, inner epithelium; × 232.
19. A small portion from a thin transverse section through the integumental region of a young ovary; *pe*, pericarp; *tc*, inner epidermis; *ii*, inner integument; *n*, nucellus; × 416.

FIG. 20. Another small segment from a thin transverse section through the integumental region of a young ovary; *pe*, pericarp; *oi*, disorganizing outer integument; *ii*, inner integument; *n*, nucellus; × 416.

21. A portion of a transverse section of the ovary during the development of the embryo showing, *pe*, pericarp; *vb*, vascular bundle; *tc*, tubular cells; *ii*, inner integument; *n*, nucellus; *al*, young aleurone cells; *en*, young endosperm cells; × 416.

22. A portion of a thin longitudinal section of the ovary during the development of the embryo; *pe*, pericarp; *tc*, tubular cells; *ii*, inner integument; *n*, nucellus; *al*, young aleurone cells; *en*, young endosperm cells; × 416.

PLATE 3. ORYZA SATIVA LINNÆUS VAR. KINAMPUPOY

FIG. 23. A small segment from a thin transverse section through the nucellar region of the ovary during the development of the embryo showing, *pe*, pericarp; *tc*, tubular cells; *ii*, inner integument; *n*, nucellus, the inner layers of which are disorganized and absorbed by the young embryo; *al*, young aleurone cells; × 416.

24. A portion from a thin longitudinal section through the nucellar region of the ovary during the development of the embryo, showing the gradual disintegration and absorption of the inner nucellar cells; *al*, young aleurone cells; *en*, young endosperm cells; × 416.

25. A portion from a surface preparation of the tubular cells; *tc*, tubular cells; *ii*, inner integument cells; *pc*, parenchyma cells from the innermost layer of the pericarp; × 416.

26. A diagrammatic sketch of a longitudinal section cut parallel to the flat surface of a rice kernel variety *malagkit*, showing, *l*, lemma; *p*, palea; *gl_1*, first outer empty glume; *gl_2*, second outer empty glume; *h*, hair; *ps*, filmy covering of the kernel consisting of pericarp and seed coats; *en*, endosperm; *al*, aleurone layer; *e*, epithelium of the scutellum; *s*, scutellum; *pl*, plumule; *r*, primary root; *ep*, epiblast; × 6.2.

27. A diagrammatic longitudinal section of the embryo cut parallel to the flat surface of the kernel; *al*, aleurone layer extended to the ventral side of the embryo; *s*, scutellum; *ep*, epiblast; *col*, coleoptile; *fl*, first foliage leaves; *gp*, growing point; *hy*, hypocotyl; *cc*, crushed cells; *en*, endosperm; *co*, coleorhiza; *ps*, pericarp and seed coats pressed together; × 28.7.

28. A segment from a thin transverse section through the aleurone region and covering of the kernel; *ps*, filmy covering of the kernel consisting of the pericarp and seed coats compressed together; *al*, aleurone layer; *og*, fatty oil globules; *pg*, protein granules; *en*, endosperm; *sg*, starch grain; × 416.

29. A diagrammatic drawing of a transverse section of a mature rice grain of *malagkit* variety; *l*, lemma; *p*, palea; *vb*, vascular bundles; *k*, keel; *ps*, filmy covering of the kernel consisting of the pericarp and seed coats pressed together; *al*, aleurone layer; *en*, endosperm; × 23.

FIG. 30. A segment from a thin longitudinal section through the region between the upper part of the scutellum, *en*, endosperm and aleurone layer; *ps*, pericarp and seed coats pressed together; *en*, endosperm; *al*, aleurone layer; *s*, scutellum; *e*, epithelium; *cc*, crushed cells; *sg*, starch grain; × 416.

31. A small segment from the outer part of a thin longitudinal section of the scutellum showing, *og*, fatty oil globules; *pg*, protein granules; × 416.

32. A portion from a thin longitudinal section through the region between the lower part of the tip of the scutellum, the upper side of the epiblast and the extension of the aleurone layer; *og*, fatty oil globules; *pg*, protein granules; × 416.

33. A segment from a thin longitudinal section through the base of the embryo; *sg*, starch grains; *en*, endosperm; *pg*, protein granules; *al*, aleurone layer; *og*, fatty oil globules; *ep*, epithelium; *co*, coleorhiza; *sc*, seed coats; *pe*, pericarp; × 416.

PLATE 4. ORYZA SATIVA LINNÆUS VAR. ELON-ELON AND MACAN

FIG. 34. A transverse section of the kernel showing the structure of the endosperm; *ps*, pericarp and seed coats pressed together; *al*, aleurone layer; *aw*, region of the abdominal white; *en*, endosperm; × 26.4.

35. A transverse section of a polished macan rice kernel; *al*, a small portion of the aleurone layer; *aw*, region of the abdominal white; × 26.4.

36. A transverse section of a polished elon-elon rice kernel; *ps*, pericarp and seed coats pressed together; *al*, portion of the aleurone layer spared from the polishing; *aw*, region of the abdominal white; × 26.4.

37. A small segment from a thin transverse section of polished elon-elon rice kernel showing that portions of the endosperm cells are also removed; *sg*, starch grains; *pg*, protein granules; × 64.

38. Another small segment from the groove region of a transverse section of a polished elon-elon rice kernel; *og*, fatty oil globules; *pg*, protein granules; *sg*, starch grains; × 64.

39. A segment from the groove region of a section of a polished macan rice kernel; *og*, fatty globules of the remaining portion of the aleurone layer; *sg*, starch grains; × 64.

40. A small segment from the lateral side of a longitudinal section of the plumule; *e*, epithelium; *pg*, protein granules; *og*, fatty oil globules; × 410.

41. A small segment from the lateral part of a longitudinal section of the primary root; *e*, epithelium; *og*, fatty oil globules; *pg*, protein granules; × 410.

42. A segment from a longitudinal section through the region between endosperm and scutellum; *og*, fatty oil globules; *pg*, protein granules; *e*, epithelium of the scutellum; *cc*, crushed cells; *sg*, starch grains; × 410.

PLATE 5. ORYZA SATIVA LINNÆUS VAR. KINAMPUPOY

FIG. 43. A group of isolated cells from a maceration of the lemma; *a*, epidermal cells; *b*, sclerenchyma cells with dentation or outgrowths; *c*, sclerenchyma cells; *d*, fragments of hairs; *e*, fibers and parenchyma cells with thick walls; *g*, basal part of the hair; × 150.

44. A group of isolated cells from a maceration of the palea; *a*, epidermal cells; *b*, epidermal cells from the region near the keel; *c*, sclerenchyma cells with dentation or outgrowths; *d*, sclerenchyma cells; *e*, fragments of hairs; *f*, parenchyma cells with thin walls; *g*, portion of the epidermis with two sclerenchyma cells with dentations in the inner part; *h*, parenchyma cells with thick walls; × 150.

45. A group of isolated cells from the maceration of the outer empty glumes; *a*, elongated cells or fibers derived from the region of the midrib or vascular part; *b*, parenchyma cells, some of which are derived from the epidermis; × 150.

46. A group of starch grains and grainlets; × 630.

PLATE 6. ORYZA SATIVA LINNÆUS

FIG. 47. Fragments from the filmy covering of the rice kernel showing the tubular cells *tc;* × 114.

48. Two fragments of the filmy covering of the rice kernel highly magnified; × 467.

49. Some fragments from the embryo; *pl*, plume; × 114.

50. Two fragments from the aleurone region of the rice kernel; *pg*, protein granules; *og*, fatty oil globules; × 114.

51. A group of endosperm cells containing starch grains and protein granules; × 114.

52. Some hair fragments adhering to the rice bran; × 114.

53. A highly magnified endosperm cell; × 467.

PLATE 7. ORYZA SATIVA LINNÆUS

FIG. 54. a–k Fragments of the rice hull mixed with the rice bran; × 60.

55. Fragments derived from the rice embryo; *a*, fragment from the primary root; *b*, and *c*, fragments from either the scutellum, epiblast or coleorhiza; *d*, terminal part of the plumule; *e*, the essential part of the embryo with the surrounding tissue removed; × 60.

56. Fragments from the outer empty glumes; × 60.

57. Fragments of hairs; × 60.

58. Some fragments from the filmy covering of the rice kernel showing the characteristics tubular cells; × 60.

59. Endosperm cells containing starch grains and protein granules, and isolated starch grains and grainlets; × 60.

60. Fragments from the stigma; ×60.

61. Fragments from the aleurone layer with the adhering filmy covering; × 60.

TEXT FIGURES

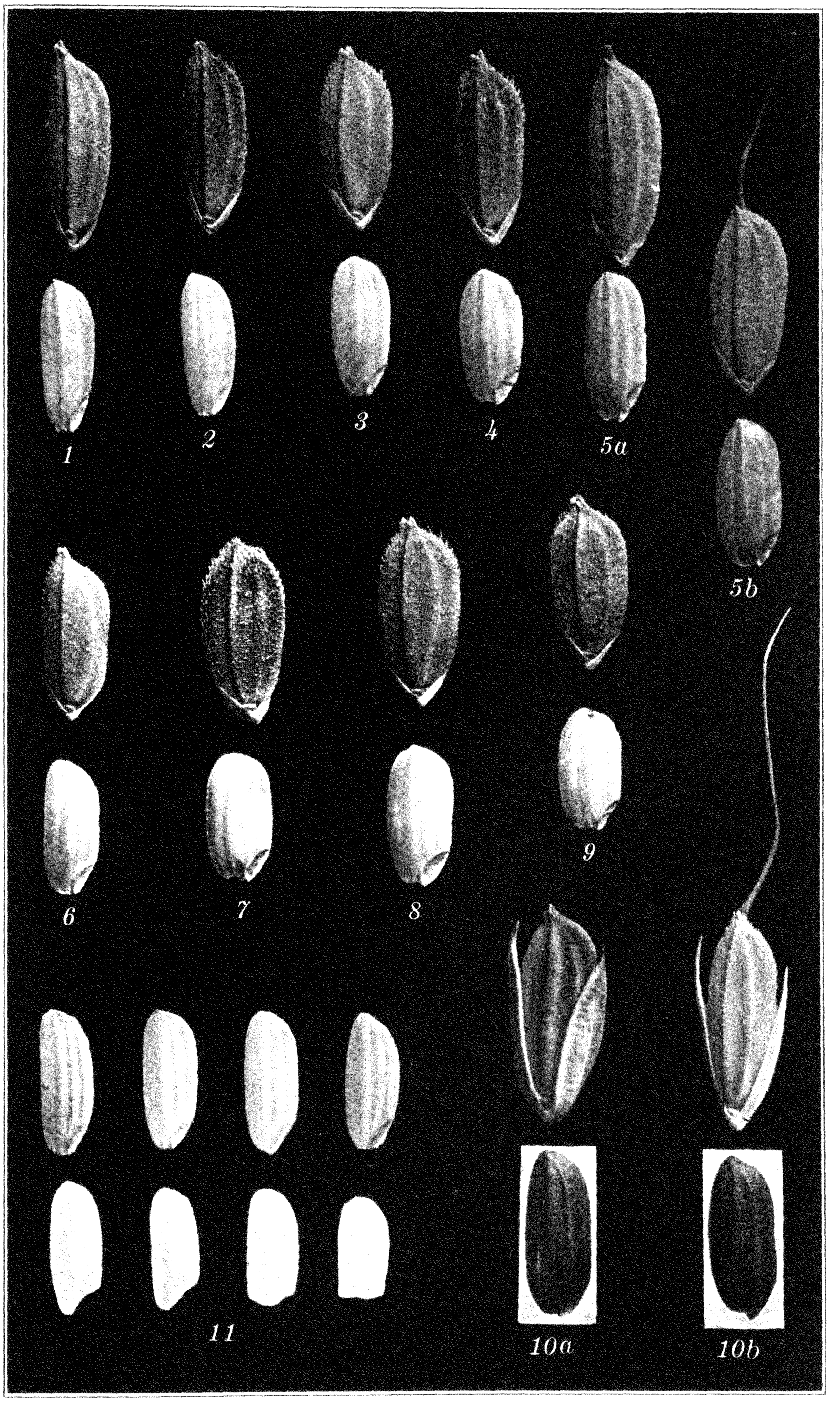
FIG. 1. An open flower of the rice variety kinampupoy; *gl_1*, first outer empty glume; *gl_2*, second outer empty glume; *l*, lemma; *p*, palea; *s*, stigma; *st*, stamen; × 10.

2. A diagrammatic drawing of a cross section of a rice flower with a portion of the lemma removed to show the relative position of its essential parts.

3. A rice floral diagram; *gl_1*, first outer empty glume; *gl_2*, second outer empty glume; *l*, lemma; *p*, palea; *k*, keel; *lo*, lodicule; *h*, hair; *o*, ovary; *st*, stamen; *vb*, vascular bundle. Reference letters are the same for figs. 3 and 4.

4. A habit drawing of a kinampupoy rice grain; *gl_1*, first outer empty glume; *gl_2*, second outer empty glume; *l*, lemma; *p*, palea; *h*, hair; × 10.

5. A habit drawing of a kinampupoy rice kernel; *en*, endosperm; *em*, embryo; × 10.



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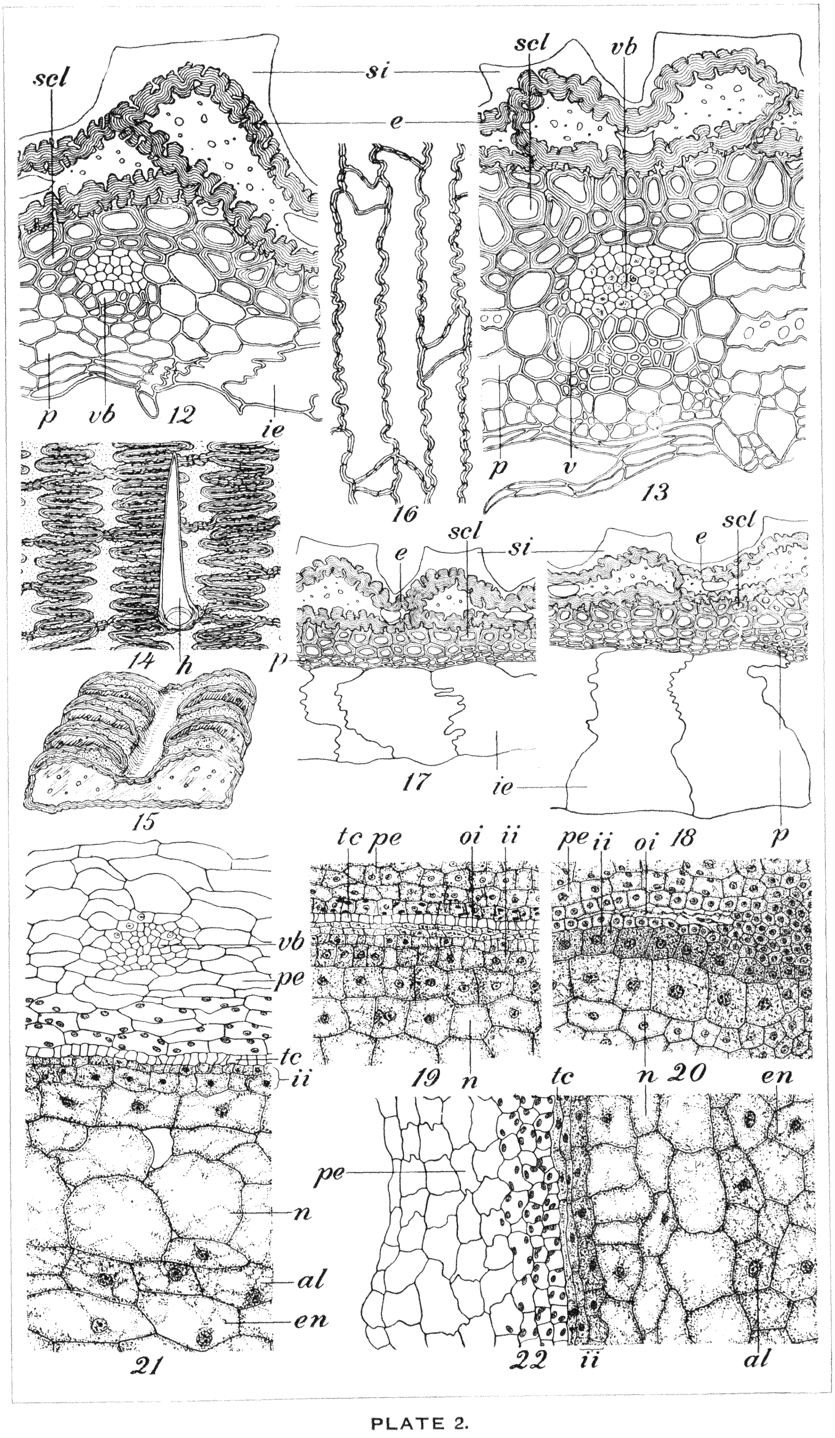

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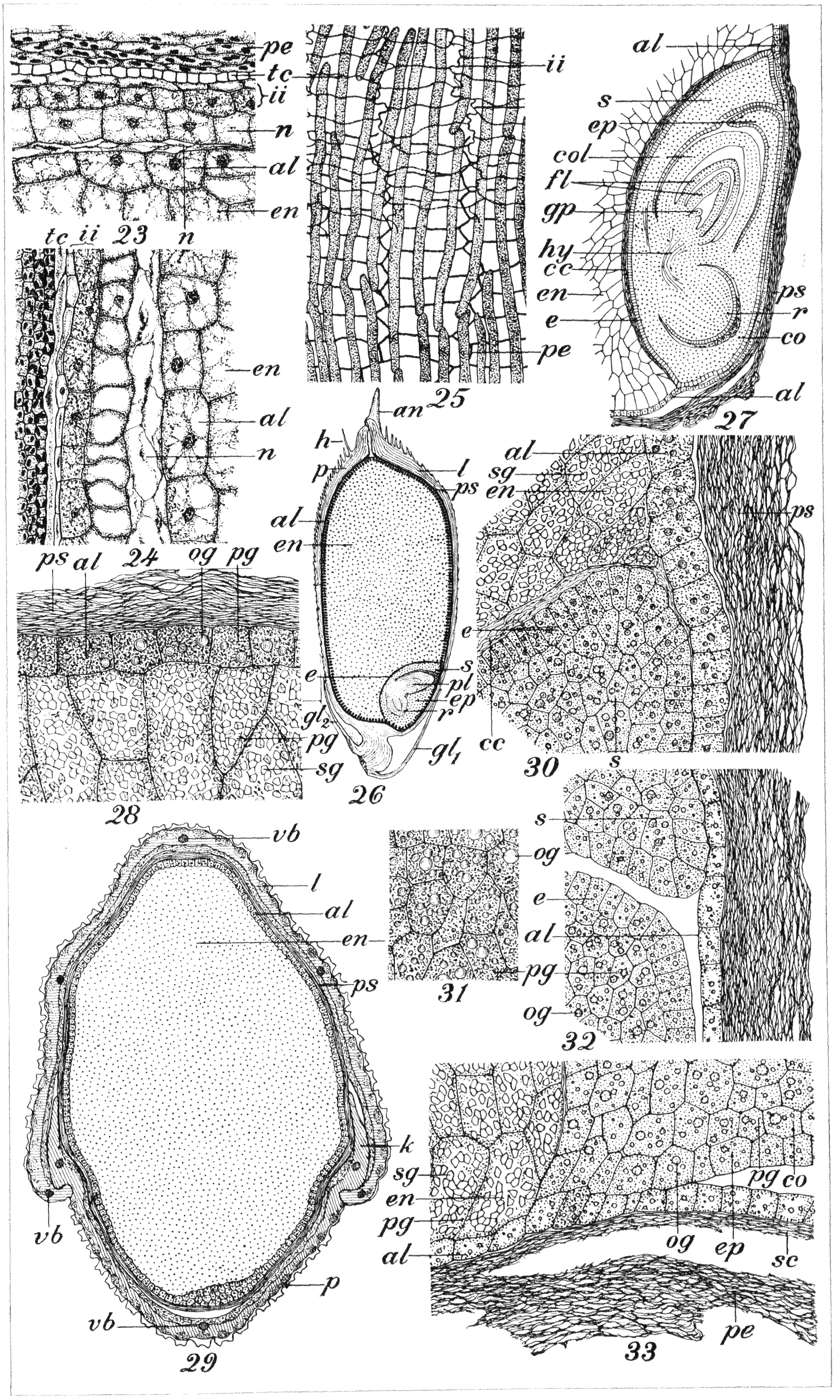
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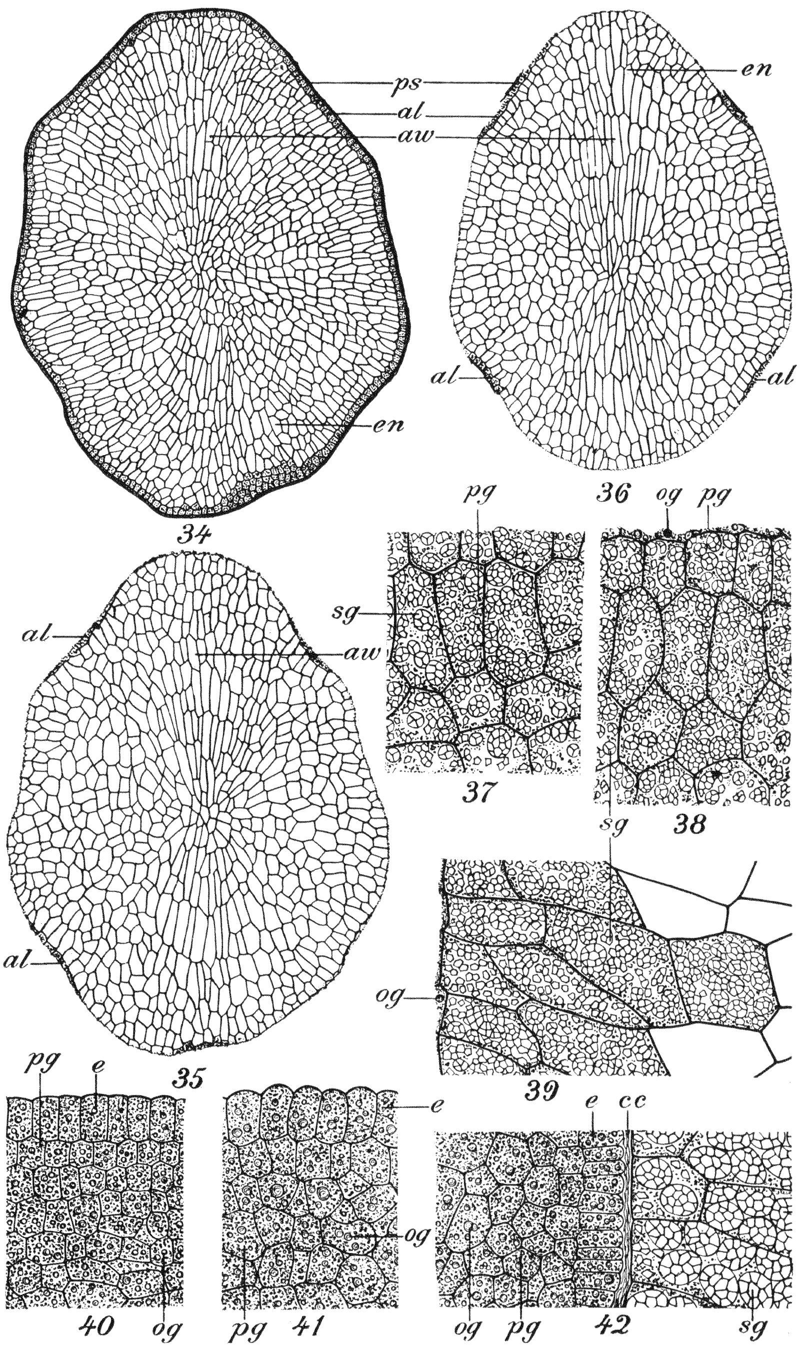
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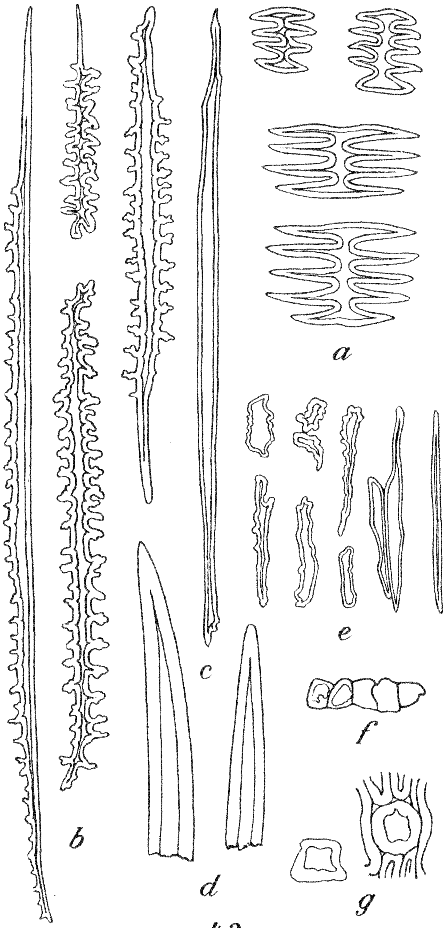

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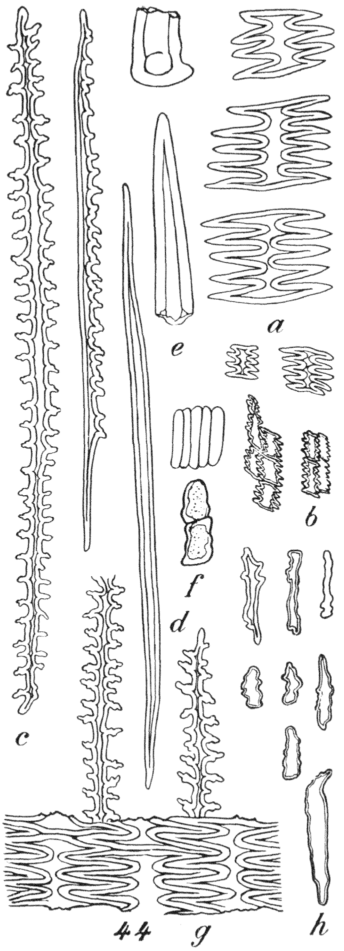

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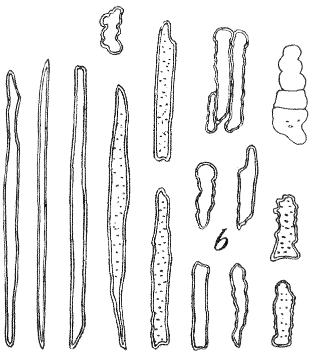

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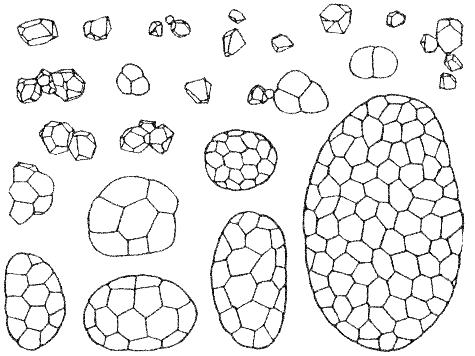

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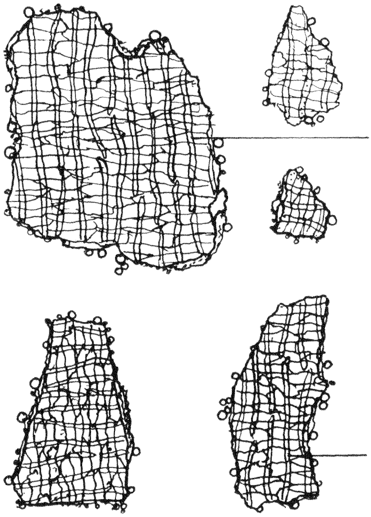

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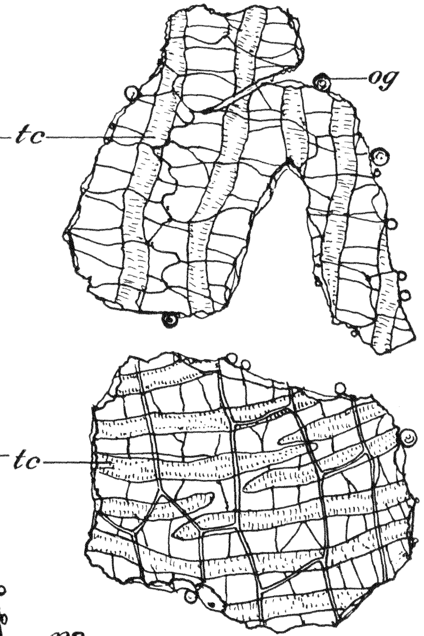

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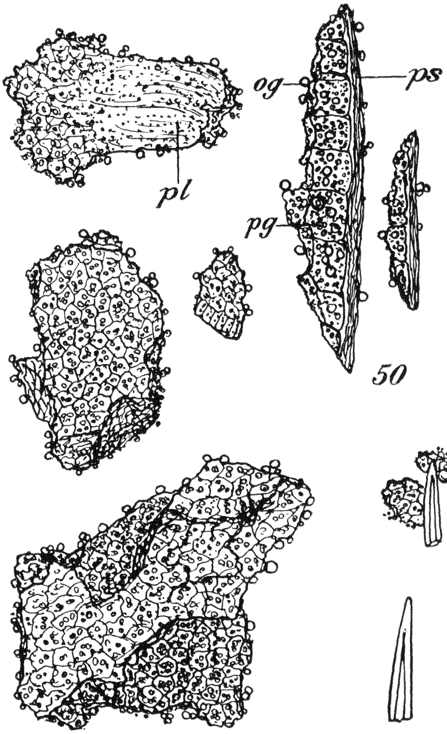

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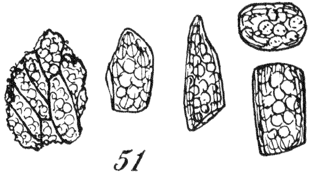

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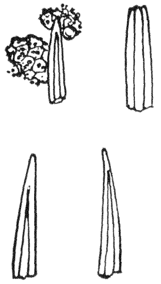

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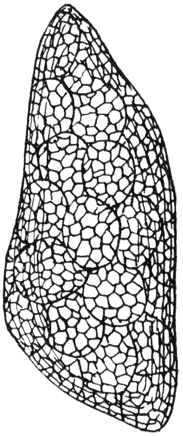

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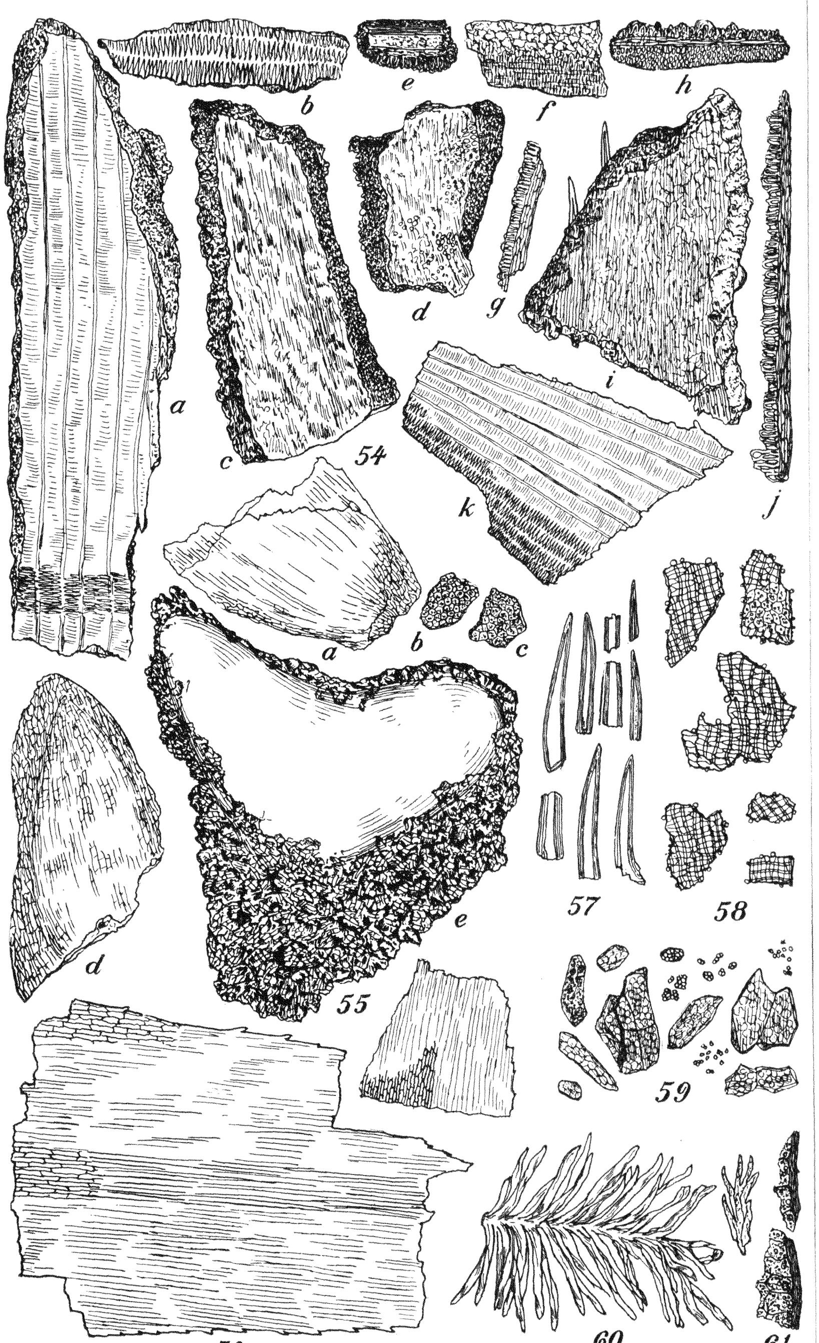

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